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THE RELATION OF FUNGUS AND ALGA IN LICHENS.

GEORGE JAMES PEIRCE.

IF one did not constantly read, even in the newest text-books for older[1] as well as for younger students,[2] that the association between fungus and alga in lichens is uninjurious to the latter, I should not feel impelled to add to the already volumi-

[1] See *Text-book of Botany*, by Strasburger, Noll, Schenck, Schimper, translated by Porter (Macmillan Company, 1898), p. 375: The fungus derives its nourishment saprophytically from the organic matter produced by the assimilating alga, without at the same time behaving as a parasite and injuriously interfering with its vegetative activity.

In the fourth German edition (received by me, Jan. 19, 1900, as a separate) Schenck says, p. 336: Was das Verhältniss von Pilz zu Alge anbelangt, so umspinnt der Pilz mit seinem Mycel die Algenzellen, schliesst sie in ein Hyphengewebe ein und ernährt sich von den durch die assimilirenden grünen Algenzellen erzeugten organischen Stoffen; er kann aber Haustorien in die Algenzellen hinein entsenden und sogar deren Inhalt aufzehren.

[2] See Coulter's *Plant Structures* (D. Appleton & Co., 1899), p. 80: In the case of lichens the symbionts are thought by some to be mutually helpful, the alga manufacturing food for the fungus, and the fungus providing protection and water containing food materials for the alga. Others do not recognize any special benefit to the alga, and see in a lichen simply a parasitic fungus living on the products of an alga. In any event the algæ are not destroyed, but seem to thrive.

nous discussion of symbiosis in lichens. In spite of all the evidence, old and new, and in spite of common sense, the lichens are only too often described as furnishing the most perfect examples of the mutually beneficial association of two utterly different kinds of organisms,—one of these able to lead a normal and perfect existence when by itself, the other absolutely dependent for food upon other organisms, living or dead. Let me, therefore, once more direct the attention of biologists to a scrutiny of these peculiar forms.

Every one now admits that lichens consist of two distinct and separable parts, of colorless fungus-like hyphæ, which form the greater part of the mass of the lichen, and of chlorophyll-containing alga-like cells, known as gonidia. Repeatedly it has been shown that the gonidia of lichens are not merely alga-like, but are algæ, often found free in nature, growing not only on the same surfaces as furnish the seat of attachment of lichens, but on many others also, growing and multiplying as healthy individuals whenever external conditions make active life possible, passing over other periods in one or another of the resting conditions known to biologists. No one now questions that lichen gonidia are algæ, and that with due care gonidia can be identified with already known species of algæ found outside of lichen associations. Identification on mere inspection of the gonidia in the lichen is not always possible, nor would it always be correct. For example, Hedlund[1] says that the alga which forms the gonidia in species of Micaria usually looks like Glœocapsa and frequently occurs on rotten wood, but that, when cultivated on this wood under abundant illumination and free from fungus enemies or algal competitors, the alga multiplies rapidly, becomes deep green, the daughter-cells separate, and none has the thick gelatinized wall which is one of the characters of Glœocapsa. Conditions wholly external to the algal cells, especially such influences as affect their freedom, cause these cells to depart from their Protococcus type and to develop qualities and habits characteristic of a wholly

[1] Hedlund, T. Kritische Bemerkungen über einige Arten der Flechtengattungen Lecanora, Lecidea, und Micarea. *Bihang till K. Svenska Vet. Akad. Handlingar*, Bd. xviii. Stockholm, 1892.

different genus. Assuming that Hedlund's experiments were conducted with sufficient cleanliness to prevent Protococcus from replacing Glœocapsa, this return from Glœocapsa-like characters to the original Protococcus characters is interesting evidence of the influence of living competitors (other algæ) and enemies (fungi), as well as of lifeless forces (light, food, etc.), upon the appearance of living organisms. Since small algæ are so modified, both inside and outside of the lichen body, by external influences, their identification and the identification of gonidia become in some instances matters of difficulty, in which experiment must play an important part.

As to the fungus-like component of lichens, all are now agreed that the hyphæ are fungus, but the identity of any fungus component of lichens with species of fungi living otherwise is difficult to prove and is absolutely denied by many. According to Reinke,[1] the fungus components of the lichens of to-day came from fungi no longer existing as distinct species. That this is necessarily true it is impossible to see; that it is true is hard to believe, for, as has been shown above for the gonidia, the other organisms with which it is associated, as well as the lifeless forces to which it is subjected, may so influence an organism that its appearance and behavior will be profoundly modified. Although Möller's[2] now classical experiments in cultivating the fungus components of certain simple lichens on artificial media were successful as far as they went, they did not go so far as to show that the fungus could reproduce itself by ascospores formed in normal apothecia, and, after all, only lichens of simple thallus form were cultivated at all. It is only natural, but also greatly to be regretted, that the extremely slow growth of lichens and of their fungus components has deterred most botanists from experimenting on these interesting plants. Reinke's view can be proved or disproved only by successful culture of

[1] Reinke, J. Abhandlungen über Flechten, III. *Jahrb. f. Wiss. Bot.*, Bd. xxviii (1895), p. 64: Kein Flechtenpilz ist bisher im freilebenden Zustande beobachtet worden — abgesehen von den Basidiolichenen — und es hat demnach den Anschein, dass alle Pilze, aus denen sich Flechten entwickelt haben, als Pilze zu Grunde gegangen sind.

[2] Möller, A. Ueber die Cultur flechtenbildender Ascomyceter ohne Algen. *Inaug. Diss.* Münster, 1887.

the fungus from spore to spore, and whether or not we believe with him that the fungus components of lichens no longer exist by themselves in nature, we certainly must call them fungi.

What is a fungus? However a systematist might answer this question, a physiologist would say that a fungus is a low dependent plant, demanding at least non-nitrogenous food in a state of comparatively high elaboration (sugar, fat, oil, or similar carbon compounds), since it is unable to manufacture such food for itself. It follows, therefore, that a fungus must be either parasitic or saprophytic, or, to follow the newer terminology,[1] metatrophic or paratrophic. When a fungus enters into association with an alga to form a lichen, the fungus allies itself with an independent plant, one able to manufacture all of its own food. The lichen is then composed of a dependent plant which must receive elaborated food, and of an independent plant which needs only food materials and light in order to take care of itself. What then is the nature of the association between these two? Reinke[2] and his sympathizers believe (*a*) that the association is consortism; (*b*) that the two members of the consortium are dependent upon and beneficial to each other; and (*c*) that the consortium is autonomous. On the other hand, many botanists, probably in the minority at the present moment, see in this association not a mutually advantageous association, but the parasitism of one plant upon another. Reinke,[3] de Bary,[4] and many others assert that the association of fungus with alga in lichens cannot be simple parasitism because, if this were the case, the fungus would consume the alga, and that would be the end of the association. Such a conclusion is not required by the evidence. It must first be shown that the influence of the fungus is so violent and so exhausting that the alga is not able, by producing slightly more food, by refraining from less economical ways of repro-

[1] Fischer, A. Vorlesungen über Bakterien, pp. 47, 48. Jena, 1897.

[2] Reinke, J. Abhandlungen über Flechten. II. Die Stellung der Flechten im Pflanzensystem. *Jahrb. f. Wiss. Bot.*, Bd. xxvi, pp. 524–542, 1894.

[3] Reinke, J. *Loc. cit.*, Bd. xxvi, p. 530, etc.

[4] de Bary, A. Die Erscheinung der Symbiose. Strassburg, 1879.

duction (*e.g.*, zoöspore formation), by dividing in certain planes instead of in others, etc., to meet the extra demand made upon it by the fungus and to form some cells which are affected only indirectly, if at all, by the fungus.[1]

On these points a few remarks may be made. In the first place, those algæ which form the gonidia of lichens will grow and multiply faster under almost any conditions than the fungus, and they grow and multiply in lichens less rapidly than under favorable conditions outside. In the lichen itself they grow and multiply very rapidly at times, much more rapidly than the fungus. For example, the gonidia in a fragment of *Ramalina reticulata*, the California lace-lichen, may be made to grow and to divide very rapidly by placing the piece in water in the comparative warmth of the laboratory in winter. The whole lichen does not grow; only the gonidia multiply and grow; the fungus grows but little, if at all. Out of doors such conditions frequently occur in all lichens. During warm rains or fogs, or dews, the gonidia have the advantage; they multiply and grow much more rapidly than the fungus; many gonidial cells recover what they had lost by too intimate association with the fungus. In this way new generations of gonidial cells are produced which continue the race in the lichen body and thereby prevent the fungus from devouring all at once. In other words, though the fungus may be parasitic upon the alga, the more vigorous alga is not wholly and at once consumed by its parasite, whatever may be the ultimate fate of the gonidial cells one by one.

Having seen that the association of fungus and alga in lichens is not destructive to all the algal cells at once, it must be shown whether the fungus is destructive or injurious to any. In all lichens the hyphæ and gonidia are in most intimate contact, the hyphæ either closely clasping the gonidial cells or filaments, or actually sending one or more haustoria into the separate gonidial cells. As a result of such intimate contact, osmotic movement of food and other substances must take

[1] Hedlund, T. *Loc. cit.* Peirce, G. J. The Nature of the Association of Alga and Fungus in Lichens. *Proc. Cal. Acad. Sci.*, Third Series, Botany, vol. i, No. 7, 1899.

place between the hyphæ and the invested gonidia. That such a movement does not take place it is impossible to believe unless one assume that the nature of the limiting membranes of algal and fungal cells is such that osmosis is a physical impossibility. This assumption would be self-destructive, however, for if these membranes were impervious to the dissolved substances in the algal and fungal cells, all osmosis would be impossible, and the cells would all die from lack of food and water. There must then be osmotic movement between fungus and alga. In obedience to the ordinary laws of osmosis there would be movement of dissolved substances from regions of more to regions containing fewer molecules of these substances. The alga under the influence of light manufactures complex nutritious non-nitrogenous carbon compounds, which are at times, if not always, in soluble forms. These substances would tend to migrate from the algal to the fungal cells. This physical phenomenon is of the utmost physiological importance to the fungus, for it thereby gains the food it needs. Such a transfer is inevitable so long as the conditions of intimate contact, of permeable membranes, of supply of food and demand for it continue the same. If the demand for food by the fungus or any part of it exceed the ability of the alga, or of any algal cell, to manufacture enough for its own needs and those of the fungus, the fungus will consume the alga itself. The numbers of empty gonidial cells in the lichen body are sufficient evidence of this,[1] but this evidence cannot always be found, for only at times does the fungus demand so much of the alga that the body substance of the alga must be given to feed the fungus.

The slow-growing fungus component of the lichen draws food from the more rapidly growing algal cells in which the food is manufactured. Such taking of food is evidently parasitism. It can be nothing else. The intimacy of contact of hyphæ and gonidia precludes any other supposition than that the hyphæ osmotically draw food from the necessary and helpless algæ. If the algæ grew and multiplied less rapidly, or if the fungus grew more rapidly, or if the alga made less and the fungus demanded more food, or even if fungus and alga always

[1] Peirce, G. J. *Loc. cit.*, p. 225, etc.

grew at a constant rate instead of the alga sometimes growing much faster than the fungus, the parasitism of fungus on alga would result much sooner in the destruction of each algal cell. As it is, the fungus destroys the algæ, but only by degrees, and so slowly that a new generation is mature before the first is consumed.

If there is osmotic transfer of non-nitrogenous food from alga to fungus, there may also be osmotic transfer of something else from fungus to alga. Presumably there is. De Bary, Reinke, and others say that the fungus supplies the alga with water and mineral salts. Undoubtedly this is true, but I doubt this being other than by the capillary movement of columns or films of water, holding mineral salts in solution, between and along the hyphæ which, running more or less parallel with one another, form continuous capillary tubes from the substratum throughout the body of the lichen. By this means the fungus certainly does supply the alga, but so would cotton fibres or glass tubes similarly placed. It cannot be questioned that, in its position in the lichen, the alga needs to have water and mineral salts conducted to it, but its position is not of its own seeking, natural, or necessary, or at all evidently advantageous. In its natural habitat the alga (Protococcus, Glœocapsa, Nostoc, etc.) could supply itself with aqueous solutions of needed food materials without the intervention of a dearly paid servant.

It is alleged by some that what the fungus obtains from the alga is merely the excess of organic matter elaborated by the latter, and that the alga is manured by the waste substances produced by the fungus. Such conceptions of the physiology of living organisms are anything but definite. According to this, plant cells and plant bodies are leaky affairs from which nutritious substances ooze in appreciable quantities. Every one knows that this is not true. The ooze theory of the nutrition of the associates in the lichen must, therefore, be abandoned.

It is said that, if the fungus were simply parasitic upon the alga, the algal cells would not so rapidly multiply, would not look so healthy as they often do in the lichen thallus. Besides the reason already given for this, it seems to me certain, from my study of *Ramalina reticulata*, and of some others

of our California lichens,[1] that the algal cells invested or penetrated by fungus filaments try by frequent division to produce cells which shall be quite free from contact with hyphæ. The contact of the hypha exerts an irritation which induces more frequent division, and at a smaller size than normally takes place in gonidia not in contact with hyphæ. Gonidia may frequently be found in the lichen thallus, large and wholly free from contact with hyphæ. These gonidia divide less frequently than the others and are by all means nearest the typical algal cells of the same species in size, color, form, thickness, and composition of wall, etc. These free gonidia are fed with water and mineral salts, are protected against drought and certain other dangers, and may really benefit by being enclosed in a mass of fungus hyphæ. Gonidia which are not merely loosely enclosed in the lichen body but are tightly invested if not penetrated by hyphæ, although they may be supplied with food materials and may be protected, are also robbed of part of the food they elaborate and are actually irritated by their associate. That they are ultimately sucked dry by the fungus I have recently shown in the paper already referred to.

In an increasing number of lichens it is being found that the hyphæ not merely closely invest the gonidia, thereby making possible the osmotic movement of elaborated food from alga to fungus, but that the hyphæ actually penetrate the gonidia by haustoria. These haustoria either apparently merely penetrate the cell-wall, pushing back the protoplasm, or they actually penetrate the protoplasm also. Where it is possible to demonstrate in any species of lichen that haustoria actually occur in the gonidia, there can be no doubt that the association is of unmixed injury to the alga, and of unmixed benefit to the fungus. The movement of aqueous solutions through the haustoria from the gonidia to the hyphæ is different, however, only slightly in degree and not at all in kind from that which takes place between gonidia and closely clasping hyphal branches. The absorption of food is easier, the parasitism more perfect and more evident, when haustoria connect hyphæ and gonidia

[1] Peirce, G. J. *Loc. cit.*

than when the hyphæ merely enclose the gonidia, but the hyphæ are parasitic in both cases.

The foregoing argument, based on observations reported in detail elsewhere,[1] shows, I believe, that there are no physiological or structural reasons for supposing that the association of fungus and alga in lichens is other than the actual parasitism of the former upon the latter. If the lichens are merely fungi and algæ associated together as parasite and host, these associations are no less remarkable and interesting, though less moral, than if they were ideal alliances for mutual aid. Experiment has still to show whether the characters of the lichen thallus are formed by the fungus mainly, or by the fungus under the influence of its host, how far substratum, illumination, nutrition, etc., affect the character of the association. Experimentation on lichens demands endless patience and considerable skill, for lichens grow with prodigious slowness, and the chances of a culture becoming infested with mould or bacteria before it has accomplished the purpose designed are only too great. Some of the problems puzzling systematic lichenologists can be solved only when illuminated by experimental culture of the fungus component of the lichen thallus under definitely known conditions.

STANFORD UNIVERSITY, CALIFORNIA,
January, 1900.

[1] Peirce, G. J. *Loc. cit.*

A FLAGELLATED HELIOZOAN.

HOWARD CRAWLEY.

In some water taken from the pond in the Botanical Gardens at the University of Pennsylvania, in August, 1899, the two Heliozoa here figured were found.

Of these, that shown in Fig. 1 possessed a typical heliozoan body of foamy protoplasm. There was a clear, colorless outer layer, while the central portion consisted of an aggregation of small spherical bodies, greenish, reddish, and yellowish in color. The nucleus was invisible, and a contractile vacuole was not observed.

The most striking feature of the animal was the pseudopodia. These were of two kinds. The longer closely resembled those of Actinophrys. They projected in a more or less radial direction and showed considerable freedom of movement, frequently sweeping through large arcs. They always, however, preserved their straightness. At different times they varied greatly in length, and were often wholly withdrawn.

The shorter pseudopodia were extremely delicate strands of protoplasm that projected radially from the surface of the animal. The outer end of each of these was modified in such a way as to render it more conspicuous, but I was not able to determine the exact nature of this modification. In the specimens that were observed, the entire system moved in concert, the movement consisting in an alternate lengthening and shortening of the pseudopodia. Fig. 1 shows them at the greatest length that I observed. In such cases the spherical body of the animal appeared as if inclosed by a definite ring. At other times these pseudopodia were wholly withdrawn.

The animal was highly polymorphic, and occasionally, when all the pseudopodia of both kinds were drawn in, its shape departed so far from the spherical that it might have been taken for a sluggish Amœba.

On account of the clear cortical layer, the color of the central mass, the two kinds of pseudopodia and the nature of their movements, and the invisibility of the nucleus, the animal bears a close resemblance to *Vampyrella lateritia*, as described by Leidy ("The Fresh-Water Rhizopods of North America," *U. S. Geol. Sur.*, Vol. XII, Washington, 1879). There is a discrepancy in the nature of the terminal modifications of the shorter pseudopodia. Leidy states that these resemble the head of a pin, which was not the case in the

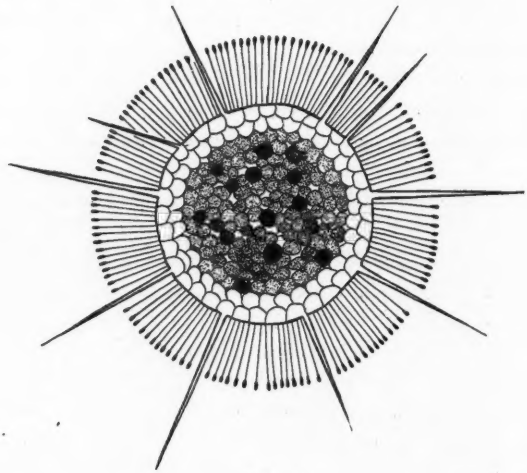


FIG. 1.

animal that I found. Nevertheless, the appearances tally so closely in all other respects that it may be referred to that genus.

The second heliozoan, shown in Fig. 2, was exactly like the first in all respects but one. The size, 80 μ in diameter, was the same. The long pseudopodia were identical in both animals, and the bodies, with their clear cortices and colored central masses, wholly alike. The difference consisted in the fact that the short pseudopodia of the form shown in Fig. 1 were represented in the other by a mantle of flagella. This whole system moved in unison, but the movement of each individual proto-

plasmic process was the lashing of a flagellum, and not the beating of a cilium.

While the spores of Heliozoa are in several cases flagellula, the possession of a series of flagella by the adult forms has been noted in but one other case. Eugène Penard ("Sur un heliozoaire nageur, Myriophrys paradoxa, *gen. nov., sp. nov.*," *Arch. Sci. Phys. et Nat.*, Tome IV, No. 9, pp. 285–289, Pl. III, 15 Septembre, 1897) describes a single individual which he

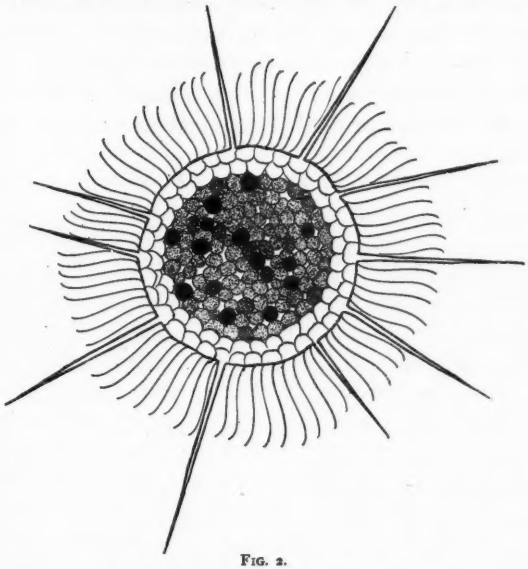


FIG. 2.

found in fresh water, also in August. This animal was about 40 μ in diameter. It was furnished with pseudopodia of the Acanthocystis type, and possessed an external skeletal layer beset with minute scales (*écailles*). There was a large contractile vacuole and an evident nucleus. It therefore will be seen that in several essential characters it differed wholly from the form here described. Concerning the flagella, Penard says: "On pourrait plutôt comparer ces cils à de petits flagellums, qui, par leur abondance, formeraient une véritable chevelure."

Penard considered the flagellated condition to be permanent,

and created for the organism a new genus and a new species. He saw, however, but one individual. I was more fortunate in that I found many individuals of the two kinds that I have figured.

It is known that a pseudopodium may turn into a flagellum, and, conversely, that a flagellum may turn into a pseudopodium. This, together with the fact that these two animals were identical in all respects but one, and that they occurred side by side in the same drop of water, renders it very probable that they are only different conditions of one and the same animal. There seems, then, no good reason for creating a new name, and I accordingly suggest retaining that used by Leidy, *Vampyrella lateritia*, even though the definition of this species must be somewhat enlarged.

HARVARD UNIVERSITY, Feb. 5, 1900.

REACTIONS OF INFUSORIA TO CHEMICALS: A CRITICISM.

H. S. JENNINGS.

In the January number of the *American Journal of Physiology*, Garrey[1] gives the results of extended experiments on the effects of chemicals in causing motor reactions in the flagellate Chilomonas. From the chemical side the paper is a valuable one, as being the most thorough study yet made of the specific effects of chemicals in causing reactions in unicellular organisms, and in treating the subject from the standpoint of modern physical chemistry. On the other hand, that portion of the paper which treats of the part played in the reactions by the organisms seems to me much less successful, and it is my purpose to point out certain criticisms on this part of the work.

Garrey found that the motor reactions of Chilomonas are set strongly in operation by certain chemicals, "very swift shooting movements being induced," so that the organisms, as a result of these movements, soon leave the sphere of influence of the substance in question. This effect is termed by Garrey "chemokinesis"; it is analogous to that which I have called "negative chemotaxis" in Paramecium. The chief portion of the paper is devoted to determining the relative strength of various chemicals in causing this reaction, and the exact factors in the solutions that produce the effect; interesting and valuable results are here brought out.

In certain organic acids (acetic, butyric, lactic) and their salts Garrey found the flagellates to form aggregations, as Paramecium does in solutions of CO_2 and acids of all sorts;[2]

[1] Garrey, Walter E. The Effects of Ions upon the Aggregation of Flagellated Infusoria. *Amer. Journ. of Phys.*, vol. iii, pp. 291–315.

[2] Owing to the failure of his attempts to repeat my experiments with solutions of CO_2 and inorganic acids, Garrey denies my results with Paramecia. His failure was unquestionably due to neglect to fulfill the necessary experimental conditions. I have never known the experiments to fail when properly carried out.

these aggregations, he says, are due to "true chemotropism." In that portion of the work which deals with the way in which these aggregations are formed and with the part played by the organism, it seems to me that Garrey neglects certain facts that are absolutely fatal to the view of these matters which he puts forth. He did not determine the mechanism of the reactions of Chilomonas, — the exact way in which the organism moves when stimulated, — and this seems to me the first requisite for an understanding of how the reactions are brought about. Garrey's point of departure is his definition of *tropism* (which he says is the same as *taxis*).

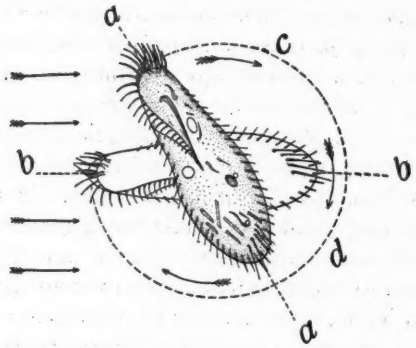
Taking heliotropism as a type, he says: "In heliotropism the organism is so oriented that its axis or plane of symmetry coincides with the direction of the rays, and symmetrical points on the surface of the body are struck by the light rays at the same angle." He then quotes with approval, for the case of chemotropism, Professor Loeb's generalization: "The essence of chemotropic orientation would then consist in the animals placing themselves in such a position that symmetrical points on the surface of the body are cut by the diffusion lines at the same angle." The movement of Chilomonas into drops of organic acid, Garrey says, is "true chemotropism," and he states that the organisms move toward the center of diffusion "as if orienting themselves to radially disposed lines; lines which may represent the paths of diffusing molecules or ions." From this one might infer that Chilomonas actually does so orient itself "that symmetrical points on the surface of the body are cut by the diffusion lines at the same angle," and then swims forward in this position, as required by the generalization; Garrey says nothing to the contrary. Yet the animal does nothing of the sort. The very elementary fact seems to have escaped Garrey that Chilomonas, as is well known, is *unsymmetrical*, so that it is impossible for it to orient itself in this manner; there *are* no such symmetrical points to be thus cut. (In Chilomonas the so-called "upper" or larger lip lies at the dorso-dextral angle of the anterior end, as will be seen by consulting Fig. 9 *b* of Pl. XLV of Bütschli's *Protozoa*, so that the animal is unsymmetrical both dorso-ventrally and dextro-

sinistrally.) Furthermore, observation of its movements shows that it makes no attempt to do the impossible; instead of retaining any such position as the generalization calls for, it swims in spirals, a certain side of the animal being always toward the inside of the spiral; as Bütschli says, they "describe rather narrow circles" (Bütschli, *Flagellata*, p. 853). These facts, of the lack of symmetry of the organism, and its swimming in spirals, might be thought to be facts of capital importance for a decision as to whether it falls under Professor Loeb's generalization or not; they are nowhere mentioned by Garrey. It is well known that the Infusoria are prevailingly unsymmetrical, so that it is quite impossible for most of them to fall within this generalization. An attempt to apply it to one of the Hypotricha, for example (see figure on p. 262), where not only the form of the body but the structure and distribution of the locomotor organs are strikingly unsymmetrical, would bring out the absurdity of the attempt, and observation of the actual movements of the organisms, as detailed in the Fifth of my Studies,[1] only accentuates the impossibility. It may be regarded as axiomatic that a principle which requires the symmetry of organisms cannot be applied to organisms that are unsymmetrical. On this account I have not previously considered it worth while, in my Studies on Reactions, etc., to show the relation of Professor Loeb's well-known generalization to the movements of the prevailingly unsymmetrical Infusoria. The generalization was evidently made from a study of bilaterally symmetrical animals, and may be of the greatest value for an interpretation of their activities; it is obviously inapplicable to unsymmetrical organisms.

I have described the mechanism of the motor reactions of Chilomonas, on pp. 231–234 of the same number of the *American Journal of Physiology*, as that in which Garrey's paper appeared. Later study of their reactions in the production of the aggregations described by Garrey has convinced me that these aggregations are produced through the mechanism of the described motor reaction, in a manner exactly analogous to the production of the similar aggregations of Paramecium in weak

[1] *Amer. Journ. of Phys.*, vol. iii, p. 249.

acids, described on pp. 314, 315, of the Second of my Studies.[1] This possibility is not discussed by Garrey, apparently because of a preconceived view that chemotropism must take place according to Professor Loeb's generalization above quoted. He says: "Jennings's motor reaction cannot account for orientation," and, therefore, that it has nothing to do with tropisms. This unsupported sweeping denial seems a peculiar way of meeting such a detailed account of the production of orientation through the motor reaction as I have given for the thermotaxis of Paramecium on pp. 334–336 of the Second of my Studies. The general proposition that a motor reaction cannot cause orientation seems still more remarkable. Consider an organ-



ism, as in the figure, lying obliquely to the line of action of the incoming stimulus, which is indicated by the four straight arrows. Its position is at first *a–a*. After the stimulus has acted for a time, the organism is found to be oriented as shown at *b–b*, with its longitudinal axis in the direction of the lines of force. Now, how can this orientation possibly take place *except* through a motor reaction? The animal has certainly moved under the influence of the stimulus from the position *a–a* to the position *b–b*, and such a movement under the influence of a stimulus is what is commonly known as a motor reaction.[2]

[1] *Amer. Journ. of Phys.*, vol. ii, pp. 311–341.

[2] Garrey's attempt to attribute to me the absurd idea that the principle of a motor reaction is new (*loc. cit.*, p. 313, note), is perhaps unworthy of mention. The comparison of the motor reaction of Paramecium with that of a muscle,

The essential feature of the characteristic motor reaction of these organisms, as I have described it, is that they turn, when they do turn, toward a structurally defined side, whatever the line of action of the stimulus. For example, the organism in the figure (one of the Hypotricha) turns to the right, in the direction indicated by the curve *c–d*. But evidently the organism may come into the position *b–b* as easily by turning to the right as by turning to the left; in the former case it must simply keep turning somewhat longer. As a matter of fact, orientation to most stimuli occurs in the Hypotricha in exactly the manner illustrated — by turning to the right. This is true for chemical, osmotic, mechanical, and thermal stimuli; whether for electric stimuli and light has not been shown.

The precision of the orientation, and whether a large number of organisms will be oriented in the same way, depends upon the question as to what influences produce the motor reaction. Suppose that in the figure the stimulating agent is something that acts steadily in lines coming in the direction of the straight arrows. Now, I have shown in the Fifth of my Studies that many of these organisms are much more sensitive at the anterior end than elsewhere, so that a stimulus at the anterior end produces a different effect from a stimulus elsewhere on the body. When, therefore, the organism is so oriented that the lines of force impinge directly on the anterior end (position *b–b*), it will, of course, be differently affected as compared with a position in which the sensitive anterior end is wholly or partly protected by the remainder of the body. Thus different reactions may be caused in the two cases; in one position the motor reflex may be caused, in the other not. If, for example, the motor reflex is caused when the lines of force impinge on even a small part of the anterior end, then the organism will not cease giving the reaction until it is oriented with anterior end directed away from the side of incoming

which Garrey makes for my information, I had already developed at length to show their identity in character, in two papers (*Amer. Journ. of Phys.*, vol. ii, p. 339; *Amer. Journ. of Psychol.*, vol. x, p. 513). I had counted it a chief result of my work that it had reduced the supposed attractions and repulsions of these organisms to a motor reflex "of the same order as the motor reflexes of higher animals," as I have expressed it elsewhere.

force. If a large number of such organisms are in the field of the force, they will soon all show a common orientation, and when they move they will all move in the same direction. *All that is necessary for orientation to take place in this way is that the organism shall be differently affected when it is in one position from the way it is affected in another position.* It is difficult to imagine any agency that can cause orientation in which this condition is not fulfilled.

When the organism is once oriented with reference to a constant stimulus, of course no further reaction is necessary; it simply keeps up the normal forward motion until this motion brings it into new relations with the stimulus, when the motor reaction is again caused, resulting in a readjustment of orientation. In the hypothetical case above supposed, if the organism swims in a curve instead of a straight line, it will soon come into a position such that the lines of incoming force impinge on the sensitive anterior end; the motor reaction is thereby induced until the animal has come again into the position where the anterior end is not thus affected.

Garrey says: "All these motor reactions have nothing to do with *tropisms*, for these motor reactions are only the expression of a very sudden change in the stimuli, while the characteristic of the tropism is the stationary condition of the stimuli." He fails to consider the fact that, stationary as the stimuli may be, the organisms with which he is dealing are *not* stationary; by their own movements the organisms come into new relations with the stimuli, and these new relations may result in the production of the motor reaction, causing a readjustment of orientation.

To summarize, the chief points which I would make in criticism of Garrey's conclusions are as follows:

1. In all work upon the reactions of organisms to physical and chemical agents, it is necessary to consider the structure and normal activities of the organisms, as well as the nature of the agents acting as stimuli.

2. Orientation such that "symmetrical points on the surface of the body are cut by diffusion lines at the same angle" (or by any other lines at the same angle) is impossible in unsym-

metrical organisms, such as are a large proportion of the Infusoria.

3. Observation of the movements of the Infusoria, both the unsymmetrical and the symmetrical, shows that they do not orient themselves even approximately in the manner above expressed, but that they swim as a rule in spirals, and orientation usually takes place through a motor reflex, characterized by the fact that the organism, when it turns, turns toward a structurally defined side.

4. A sudden change in the stimulus is not necessary to produce a motor reaction, as Garrey has stated, for the organism itself, by moving, comes into new relations with a constant stimulus, and by these new relations the motor reflex may be caused, resulting in a readjustment of orientation.

5. The gatherings of Chilomonas in drops of organic acid, described by Garrey, take place, according to my observations,[1] through the mechanism of the motor reaction of Chilomonas, described in the Fifth of my Studies. Whether this is "true chemotropism" or not depends on the definition of chemotropism.

6. The orientation of Chilomonas takes place through this motor reaction, and in general it is impossible for an unoriented organism to become oriented except through a motor reaction of some sort (except where passively moved, like a dead body).

ANN ARBOR, MICH., Feb. 6, 1900.

[1] The observations on which this statement is based are detailed in a paper by the author in the April number of the *American Journal of Physiology*.

THE BASAL SEGMENTS OF THE HEXAPOD LEG.

L. B. WALTON.

At the base of each leg in the Hexapoda are a series of segments and sclerites which enter into the composition and serve as a support of the appendage. These are the trochanter, *coxa genuina*, meron[1] trochantin, and antecoxal piece. The difficulties in the way of accounting for the origin of these segments and homologizing them in the various orders have caused morphologists more or less trouble.

By reason of the fusion which has taken place between the trochanter and femur in the Myriopoda and Hexapoda, many writers on insect anatomy hold that the trochanter is merely a portion of the femur which has in some manner become constricted so as to form an apparent but not an actual segment. The fusion, however, between the two parts is a specialization acquired during the later embryonic stages of development.[2] A similar case of ankylosis is often noticeable between certain segments of the appendages in Crustacea. Bordage[3] has advanced the theory, from observations based on certain Phasmidæ, that the two segments have become coalesced in the Arthropoda as a result of ecdysis. Since the same fusion, however, is very pronounced in the Myriopoda, particularly among the Diplopoda, where Verhoeff[4] believes the trochanter

[1] In order to distinguish between these two parts, which have been confused under the name "coxa," I have called the piece articulating with the trochanter *coxa genuina*, and the posterior lateral part articulating with the epimeron, meron (from μηρός = thigh), since its lateral margin is always found in articulation with the epimeron.

[2] The "two-jointed trochanter" of Hymenoptera [Terebrantia] appears to be a secondary modification, the lower part ["*apophysis*," Ratzeburg] being derived from the femur. This is the view held by Sharp, *Camb. Nat. Hist.*, vol. v, p. 520.

[3] On the Probable Mode of Formation of the Fusion between the Femur and Trochanter in Arthropoda. *Comptes Rendus de la Société de Biologie*, tome v, No. 28, pp. 839-842, 1898. Also *Ann.* and *Mag. Nat. Hist.*, vol. iii, pp. 159-162, 1899.

[4] Ein Beitrag zur Kenntniss der Glomeriden. 1895.

is in many cases entirely absent, it is evident that it is a characteristic of a primitive stem form, and has not arisen, as Bordage suggests, from an "ancestral form belonging to the existing Phasmids in which there was a distinct articulation between the two consecutive segments."[1] In addition to ecdysis, insisted upon by Bordage,[2] we must take into consideration various other selective factors, chief among which appear to have been mutilations by enemies. The severing of the segments, which resulted from either factor, would prob-

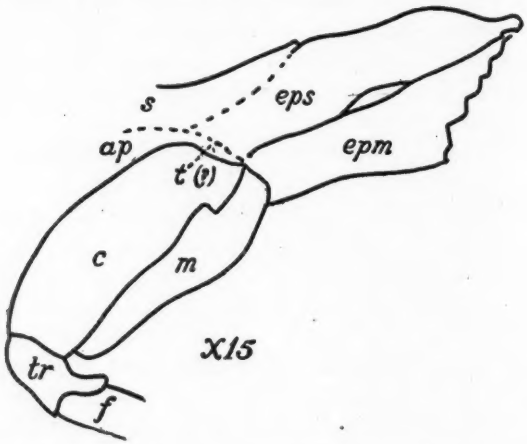


FIG. 1. — *Panorpa communis*. Metathorax; *c*, coxa genuina; *m*, meron; *eps*, episternum; *epm*, epimeron; *ap*, antecoxal piece; *s*, sternum; *t* (?), trochantin; *tr*, trochanter; *f*, femur.

ably occur near the base of the appendage, and the favored forms would be those in which the two segments were approaching the fused condition, the invagination of the chitinous wall preventing undue hemorrhage. Autotomy, which Bordage so fully explains, would undoubtedly play an important part here. It also appears advantageous to poly-

[1] I have adopted the translation as given by Austen.

[2] The position of Bordage in regard to the manner in which the fusion has come about is clearly on the side of Neo-Lamarckianism, since he attributes it to "a mechanical strain," and says that it is an "example of a character acquired by use . . . and then transmitted by heredity." This conclusion, however, as I have endeavored to show, seems unwarranted.

podial forms that a series of the appendages move more or less in unison, and it is obvious that such rhythmic motion is better maintained with the articulation of a coxa and trochanter alone than with an additional articulation between the trochanter and femur. This may be a factor in accounting for the more pronounced fusion of the two segments in the Diplopoda.

In 1893 Hansen[1] endeavored to homologize the trochanter of the Hexapoda with the ischiopodite in Crustacea. This homology was based on the supposition that the part assumed by him to be the trochantin[2] in the Cicadaria (Cicadidæ, Ful-

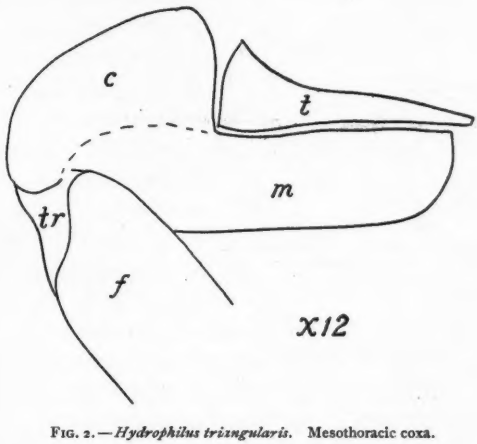


FIG. 2.—*Hydrophilus triangularis.* Mesothoracic coxa.

goridæ, Cixidæ, etc.) was the homologue of the coxopodite in Crustacea. In referring to Machilis, he has considered the trochantin of the prothoracic coxa as a primary segment, homologous with the coxopodite. From comparisons, however, with both Chilopoda and Diplopoda, we would regard the trochantin rather as a specialized character of the Hexapoda, which is absent in the Crustacea. Homologies based upon the form of the segment and manner of articulation certainly appear ques-

[1] Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen und Insecten. *Zool. Anz.*, pp. 193–198, 201–212, 1893.

[2] It seems probable that Hansen has here applied the name "trochantin" to the antecoxal piece and trochantin together.

tionable, since pronounced variations often occur within the limits of a single group.[1]

Until a closer relationship can be shown in the lines of descent of the two groups, Hexapoda and Crustacea, it would seem that an attempt to homologize the segments of the appendages would scarcely be justified. For the time being, we must assume that the segmentation of an appendage is a result brought about by certain indefinite factors, and that in these groups it does not necessarily imply a phylogenetic relationship.

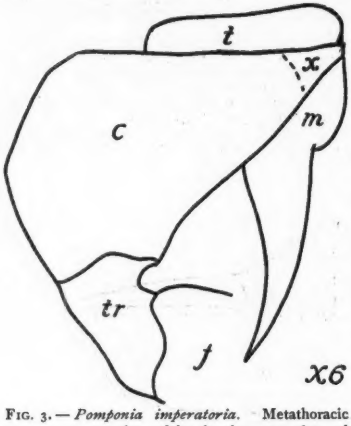


FIG. 3. — *Pomponia imperatoria*. Metathoracic coxa; *x*, area formed by development of coxal groove [Fig. 4 *c'*] and corresponding to lateral portion of *c*, Fig. 4.

That the trochanter of the Myriopoda and Hexapoda represents a distinct segment seems obvious, and that its fusion with the femur took place in some ancestral myriopod-like form appears probable.

Three sclerites, as a rule, enter into the composition of the segment to which the name coxa is given, *viz.*, *coxa genuina*, meron, and trochantin. Audouin[2] applied the name "trochantin"[3] to the lateral margin of the posterior coxa (meron) in *Dytiscus circumflexus*, erroneously believing it homologous with the trochantin on the anterior and mesal coxæ[4] of *Buprestis*

[1] Compare Arachnida, or, in Coleoptera, the metathoracic coxa of Dytiscus and Hydrophilus.

[2] Recherches anatomiques sur le thorax des animaux articules et celui des insectes hexapodes en particulier. *Ann. Sci. Nat.*, tome i, p. 125, 1824.

[3] This word had been previously used by Chaussier [Littré, *Dict. de Médecine*, p. 1632] during the latter part of the eighteenth century to designate a small process on the upper part of the femur in the human skeleton. From the note Audouin appends, he evidently felt some constraint in conforming to the custom of transferring such terms to invertebrate anatomy when no homologies could be demonstrated.

[4] In the metathorax of the Coleoptera the trochantin has been lost through specialization, although traces of it are noticeable among many forms (Hydrophilus, certain Cerambycidæ, etc.).

gigas, which he subsequently mentions.[1] Later, in his contribution to Cuvier's "Le Regne Animal," he figures the prothoracic trochantin of *Oryctes nasicornis*. The present confused terminology of these segments is due to the preceding error of Audouin. Newport[2] made a somewhat similar error by describing the anterior margin of the coxa (*coxa genuina*) in *Hydrous piceus*, as the metathoracic trochantin. Among the recent writers on insect anatomy, Packard[3] confuses the trochantin with the meron; Miall and Denny[5] hold that the occurrence of the joint applied to the coxa (trochantin) "is so partial" that it need scarcely be taken into consideration; Sharp[4] believes with Packard that the posterior part of the coxa (meron) in Panorpa represents the trochantin; while Comstock,[6] in a description of the metathorax in *Euchromia gigantea*, agrees essentially with the preceding, although he correctly figures the trochantin of the prothorax and mesothorax. Lowne[7] regards the piece

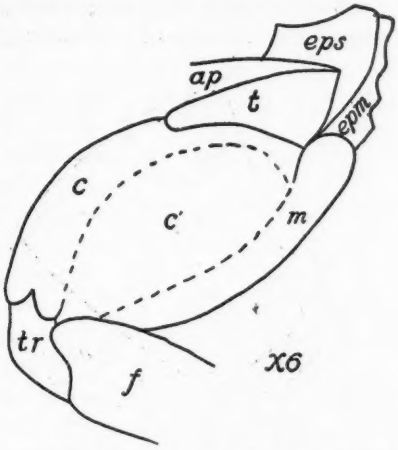


FIG. 4.—*Periplaneta orientalis*. Metathorax; *c'*, coxal groove formed for reception of femur.

[1] Étude de la poitrine ou des pattes inférieures et latérales du mesothorax. *Ann. Sci. Nat.*, tome i, p. 426, 1824. This is merely a continuation of Recherches anatomiques.

[2] Todd's *Cyclopedia of Anatomy and Physiology*, p. 916, 1835–59.

[3] Systematic Position of the Orthoptera in Relation to the Orders of Insects. *Third Report U. S. Ent. Com.*, 1880–82. *A Text-Book of Entomology*, p. 95, 1898.

[4] The Structure and Life History of the Cockroach, p. 61, 1886.

[5] *Camb. Nat. Hist.*, vol. v, p. 104, 1895.

[6] Manual for the Study of Insects, p. 504, 1895. It was due to Professor Comstock's suggestion of a possible error in considering the lateral margin of the metathoracic coxa of Euchromia as the actual homologue of the mesothoracic trochantin, that the study leading to this paper was commenced.

[7] The Anatomy, Physiology, Morphology, and Development of the Blow-Fly, vol. i, p. 179, 1890–92.

termed by him "epitrochlea"[1] as "certainly the trochantin of Audouin," ignoring his previous suggestion that one should adhere to the rule of priority. Several other writers, notably Latzel (Chilopoda), Comstock and Kellogg (Lepidoptera), and Kolbe (Lepidoptera, Trichoptera, and Panorpa), have mentioned the existence of an apparent suture in the coxa of certain groups under consideration, but without attempting to discuss its meaning.

Immediately in front of the metathoracic coxa, particularly among the Coleoptera, a small sclerite is discernible, which bears the name of antecoxal piece. This is also well shown in Cicada, some species of which (*Cicada dorsata*) possess a piece homologous with that found in the Coleoptera; while in others (*Cicada tibicen*),[2] instead of being chitinized, the part is often membranaceous in structure, and serves to retain the coxa more firmly in the coxal cavities, thus indicating its origin; and the presence of a homologous piece in the mesothorax of many Coleoptera (Passalus, etc.), occurring at the same time with the trochantin, proves that it is distinct from the latter.

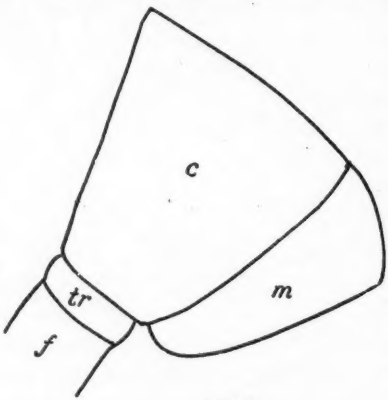


FIG. 5. — *Scutigera sp.* Coxa showing fusion of coxa genuina and meron.

The *origin* of the three pieces, *coxa genuina*, meron, and trochantin, the relative positions of which are shown in the accompanying figures, is more difficult of explanation. A striking characteristic of the Hexapoda and Chilopoda is the more or less complete fusion of the first two (*coxa genuina* and

[1] The homology of this with the trochantin appears doubtful.

[2] Although a good series was examined in which the other sclerites were well chitinized, the absence of chitinization in the antecoxal piece may be the result of immaturity. This, however, would not alter the conclusion.

meron) into the so-called coxa. Theoretically the episternum[1] and epimeron may be regarded as corresponding basal segments of these fused pieces, and taking into consideration the apparent absence of a piece homologous with the meron in the Diplopoda, we are led to the interesting inference that this group represents a class in which *each primitive metamere bears a pair of appendages*, while the Chilopoda and Hexapoda represent a widely divergent class, in which *two primitive metameres have attained a more complete fusion*,[2] *the rudimentary appendage belonging to each posterior segment fusing with the base of the functional appendage belonging to the anterior metamere*.[3] The posterior appendage would then be represented by the meron and epimeron.[4] In this case we can refer the origin of *coxa genuina* and episternum, as well as the meron and epimeron, to the same causes which produce segmentation in the appendage. The trochantin appears to be nothing more than a part of the antecoxal piece, a lateral prolongation of which became constricted off in a primitive form. Again we are confronted with the question as to the origin of the appendages in the Arthropoda, whether they are ventral or dorsal parapodia, or a fusion of the two, as in Nereis, or whether the

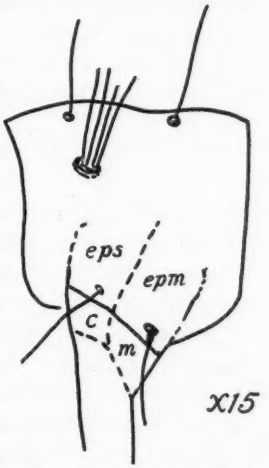


FIG. 6.—Larva of *Phryganea*. Mesothorax, showing early indications of coxa genuina and episternum fusing with meron and epimeron.

[1] Frequently the episternum appears to be cut off from the coxa by the sternum or by the trochantin, but in such cases the coxa is usually prolonged internally, so that it meets the episternum.

[2] At present there appears to be better evidence for believing that these pieces indicate a fusion of the segments than to hold that an exopodite and entopodite are represented.

[3] A study of the position and homologies of certain of the pleural and dorsal sclerites in Hexapoda and Chilopoda appears to confirm this inference.

[4] While thus far the majority of embryological evidence appears to be against this view, it seems possible that secondary modifications have caused a misinterpretation of the lines of descent.

origin was entirely independent of the parapodia. A study of Peripatus appears to throw no light on the subject under discussion, beyond indicating that in using the term "primitive metamere" we must not exclude the idea that such a metamere may in turn represent a fusion of an indefinite number of annuli. Evidence is thus added to a segment-fusion theory rather than to the biramose theory.

While it appears possible that the exopodite and entopodite in Crustacea may have developed from dorsal and ventral parapodia, in direct contrast to the manner indicated above for the Chilopoda and Hexapoda, further study may show a common origin of the two processes.

Summary.

In Hexapoda and Chilopoda the "coxa" is composed of two more or less fused segments, *coxa genuina* and meron.

The antecoxal piece results from the chitinization of the membrane connecting the coxa with the sternum.

The trochantin probably originated from a lateral portion of the same membrane.

Audouin erroneously homologized the lateral margin of the posterior coxa in *Dytiscus circumflexus* with the trochantin of the prothorax and mesothorax.

The trochanter represents a distinct segment of the legs.

The meron and *coxa genuina*, together with their corresponding basal segments epimeron and episternum, give evidence of a fusion between two primary metameres in the Hexapoda and Chilopoda.

In Hexapoda and Chilopoda the anterior metamere bears the functional, and the posterior, the rudimentary leg.

Of the primitive Hexapoda, Neuroptera [Planipennia] exhibit the most generalized condition in the development of the coxa, while in Thysanura and Orthoptera a high degree of specialization is shown.

Anatomical Laboratory, Brown University.
October 27, 1899.

NOTES ON THE PSYCHOLOGY OF FISHES.

R. W. SHUFELDT.

LAST year Dr. C. O. Whitman of the University of Chicago delivered a very able lecture on "Animal Behavior," it being one of the biological lectures from the Marine Biological Laboratory, Woods Holl, Mass.[1] In the leading paragraph Dr. Whitman very truly points out the fact that "animal behavior, long an attractive theme with students of natural history, has in recent times become the center of interest to investigators in the field of psychogenesis. The study of habits, instincts, and intelligence in the lower animals was not for a long time considered to have any fundamental relation to the study of man's mental development. Biologists were left to cultivate the field alone, and psychologists only recently discovered how vast and essential were the interests to which their science could lay claim" (p. 286). This is as true a statement as has been made in the premises in question in any connection, and the person who has paid any attention to psychological literature during the last ten years is well aware of the fact that in the discussions that have been going on there on the subject of instinct and intelligence, the psychologist has been compelled over and over again to draw upon the observations made by the biologist upon the habits and physiology of animals in order to lay down the very base for his theories in regard to the aforesaid faculties. Professor Whitman's recent researches have lent a powerful impulse to the interest taken in this subject, the more so from the fact that being a trained biologist himself, and possessed of a keen appreciation of the modern advances in psychology, he has been enabled to attack the question in the double capacity of naturalist and psychologist. So far as the writer's present information carries him, the researches of this observer have been chiefly devoted to the studying of the

[1] Boston, Ginn & Company, 1899.

habits and behavior of leeches (Clepsine), the large fresh-water amphibian Necturus, and to the various species of wild and domestic pigeons.

From these he draws very broad conclusions, so without entering upon a discussion of the theories touched upon in this meritorious memoir, for I have already done that elsewhere,[1] the present paper will take into consideration only such facts as concern the behavior of fishes. Moreover, what is here said will refer in particular but to the true bony fishes, or Teleostei, although, for aught that is known to the contrary, it is probably true of the entire group. Aside from some few well-known exceptions (Amblyopsis and congeners), that fishes possess excellent visual powers, even to the extent of keen discrimination between objects, there can scarcely be any manner of doubt. Therefore their appreciation of light and their sensitiveness to it follow as a natural consequence. Further, there is every reason to believe that fishes are so organized that they are extremely sensitive as to any disturbance of the element in which they live, when such disturbance is made within the range of the power of their nervous organization to appreciate it. Whether any fish is as sensitive in this respect as a leech (Clepsine) I think is an open question, for, as Whitman has shown, we have but to touch with extreme care with a point of a fine needle the surface of the water over a leech, when the latter is in a dish containing it, to see the animal suspend the act of respiration, *slightly* expand its body, and hug closer to the glass or china dish wherein it has been placed. This experiment must be performed with great caution, for any undue disturbance will effectually defeat the looked-for result. The very extreme sensitiveness of the creature is absolutely remarkable.

Coming now to the sensitiveness of fishes, I take occasion to quote in full a note that Professor Eigenmann furnished Dr. Whitman with for use in his paper on "Animal Behavior"; it runs as follows: "*Chologaster papilliiferus*, a relative of the blindfishes living in springs, detects its prey by its tactile organs, not by its eyes. A crustacean may be crawling in

[1] R. W. Shufeldt, M. D. Animal Behavior. *Popular Science*, vol. xxxiv, No. 3, pp. 45, 46. New York, N. Y., March, 1900.

plain view without exciting any interest, unless it comes in close proximity to the head of the fish, when it is located with precision and secured. The action is a very strong contrast to that of a sunfish, which depends on its eyes to locate its prey. A Gammarus seen swimming rapidly through the water and approaching a Chologaster from behind and below was captured by an instantaneous movement of the Chologaster, when it came in contact with its head. The motion brought the head of the Chologaster in contact with the stem of a leaf, and

FIG. 1. — The Snowy Grouper (*Epinephelus niveatus*), juv. Photographed from life by R. W. Shufeldt.

instantly it tried to capture this also. Since the aquarium was well lighted, the leaf in plain sight, it must have been seen and avoided if the sense of sight, and not that of touch, were depended upon.

"In Amblyopsis, the largest of the blindfishes of the American caves, the batteries of tactile organs form ridges projecting beyond the general surface of the skin. Its prey, since it lives in the dark and its eyes are mere vestiges, is located entirely by its tactile organs. This is done with as great accuracy as could be done with the best of eyes in the light, but only when the prey is in close proximity to the head. Coarser vibrations in

the water are not perceived or are ignored, and apparently stationary objects are not perceived when the fish approaches them. If a rod is held in the hand, the fish always perceives it when within about half an inch of it, and backs water with its pectorals. If the head of a fish is approached with a rod, the direction from whence it comes is always perceived and the correct motion made to avoid it. This reaction is much more intense in the more active young than in the adult. One young about 10 mm. long determined with as great precision the direction from which a needle was coming as any fish with perfect eyes could possibly have done. It reacted properly to avoid the needle, and this without getting excited about it."

That fishes with perfect eyes depend entirely upon them in the detection and capture of their prey is easily proved by the difference in their behavior when feeding in perfectly clear or in muddy water. This experiment can be made in a large aquarium containing a number of hungry black bass, and turning a few small yellow perch loose among them. If the water be clear, short work is made of the victims, but their capture is made less and less certain the muddier the water happens to be. It is more than likely that some of the semi-blind deep-sea fishes, as, for example, *Mancalias shufeldtii*, are quite as sensitive to disturbances of a very delicate nature of the water in their immediate neighborhood as is Amblyopsis of the Mammoth Cave of Kentucky. On the other hand, the eyes of some of these fishes have come to be of enormous size in proportion to the size of their owners, and this to gain all the available light possible. Consequently, there is probably a compensating distinction in this regard among such fish as I have here noticed; in other words, the more perfect the sight the less need of a highly organized sensitive apparatus and *vice versa*.

But now comes another question in the behavior and psychology of fishes that will require a far greater knowledge on our part of the habits and history of these vertebrates, before biologists will arrive at anything like a unanimity of opinion regarding the matter, or the observations in the premises, and the observed facts are sufficiently numerous to insure the solution of the entire problem. It involves the whole question of

instinct and intelligence and some of the knottiest points in the entire range of biology. It has been observed in fishes that many of them have the habit of "pausing before the bait" prior to making a seizure with the jaws. This, according to Whitman, has its origin in *fear*, and he studied quite closely the corresponding, though somewhat different series of acts in Necturus. It is an *instinctive* timidity rather than a strategic approach of the fish not to alarm its prey and thus defeat capture. The long and careful series of experiments made by Professor Whitman in the case of numerous specimens of Necturus, both young and old, seem to prove very conclusively that their intensely shy behavior, when approaching their prey or food, is due to an innate timidity or really fear.

Young sunfishes (Lepomis) I have studied for many years at different times and places in aquaria, and I have observed the habit in the young of that species of "pausing before the bait," or really their food, prior to taking it. The same behavior obtains in the adult sunfishes, but in them it can be overcome by education to a large extent, for I have seen them *immediately* attack in numbers one's finger when placed in the water of the aquarium containing them; whereas, when the experiment was first tried, they evidently all stood in great fear of the object, however gently it was placed in the water. A study of the young and old of Chætodon in this connection and the method of some of the species of that genus of taking their prey would be interesting.

In speaking of the marked timidity of Necturus in the taking of its food or seizing its prey, Professor Whitman says: "If this series of acts represents an organic sequence, and if the behavior as a whole takes the form determined by the organization, as seems to me beyond reasonable doubt, we have an instinct the history of which may be coextensive with the evolution of the animal. We stand at the end of an interminable vista. The specific peculiarities of organization in Necturus form but an infinitesimal element of the problem. Scarcely a feature of the instinct belongs exclusively to Necturus. It is at least widely diffused among vertebrates, especially among fishes. The differences in the manner of execution among dif-

ferent forms, so far as I have observed, are of quite a superficial nature. The instinct evidently has its root in the general instinct of preying, which is doubtless coeval with animal organization" (p. 307).

In the adults of some species of fish it is very evident, in the matter of seizing their prey, that the elements of both *hesitation* and fear are entirely absent, as witness the bold rush of the pike to capture a minnow, or the manner in which a trout or a salmon instantly takes the *artificial fly*. Hundreds of similar cases could easily be cited.

This autumn the writer has been making photographs of living rare fishes at the building of the U. S. Fish Commission at Washington, D. C., and among them were some beautiful specimens of the young of the Snowy Grouper (*Epinephelus niveatus*) (see figure 1) and the Big-eye (*Pseudopriacanthus altus*). Both of these species exhibit a most remarkable behavior under certain conditions. The Snowy Grouper, for instance, when overteased in any way, or sometimes without even that provocation, or when its food is presented to it, whether the act be voluntary or involuntary, passes through a peculiar fit or spasm, simulating all the symptoms of a dying fish. Not only this, but the specimen so behaving *changes in color* from the normal brownish-black to a pale leaden hue, and as the spasmodic stage of the attack subsides, the fish comes to lie perfectly motionless upon its side, or else floats on the bottom, belly upwards. It will remain in this condition for nearly half an hour, when signs of animation again make their appearance, and the individual gradually assumes its former normal condition and color. The Big-eye is another species exhibiting somewhat similar attacks under nearly like conditions, but this species, I am told, sometimes dies in one of its more violent spasms. It is a well-known fact that some species of large fishes that prey upon smaller species will not devour them unless captured when making an exciting attempt to escape and in full vigor of health. They will not touch a dead specimen, or even one in the act of dying. I have noticed this especially in the case of pickerel. Now this peculiar fit that seizes the young of the Snowy Grouper may be due to the result of an acute reaction caused by fear; but, on the

other hand, it may be something of the nature of "feigning death," and thus be useful to the form in nature. Possibly there may be some large form in the seas that preys upon young Snowy Groupers, and *prefers* to take them only in the excitement of actual chase, and ignores a dead or dying one. If this chance to be true, these peculiar "fits" of Epinephelus and Pseudopriacanthus are in favor of the preservation of the species. Indeed, we are hardly yet upon the threshold of our knowledge of the habits and *behavior* of fishes in nature, much less are we enabled to solve the problem in an untold number of cases, how in any special instance any special act in a fish's behavior first arose, and whether that act is wholly or only in part prompted by instinct. Whitman's "Animal Behavior" and similar memoirs will in the future have a beneficial result in stimulating investigation and research in such directions.

A NEW MUSEUM TABLET.

FRANK C. BAKER.

For the past five years the writer has been experimenting upon a durable and convenient museum tablet, which would remain perfectly flat when the label and specimens were attached, and which would give the largest amount of exhibition room with a minimum of label area. Such a tablet has been worked out by the writer and a short description of it may be of interest to those having the same problem to meet. I might say, however, that the idea was first conceived while examining the tablets in the American Museum of Natural History, New York, upon which are mounted Hall's types of fossils.

The foundation is No. 20 binder's board, which has been found quite heavy enough for all practical purposes. About the edge of this is bound black gummed paper, similar to that used for binding lantern slides. The center for the specimens and label is next prepared, and for this the writer has selected a grade of manilla cardboard identical with that used for herbarium genus covers; this is of a rich cream color and does not fade when exposed to the light, and presents a surface admirably setting off the black, full-faced type used. At a first glance a finished tablet appears as though made of ivory. This board is cut just enough smaller than the tablet to allow a black border of an eighth of an inch. For very light specimens a black center is used, cut just small enough to allow an eighth of an inch of light margin between it and the black border of the tablet, and also to leave room for the label which is generally 3×1 inch.

In securing a good black the writer was compelled to resort to a thin black paper used by paper-box manufacturers, as no printer seemed able to print a uniform black, the first ones printed being gummy, and the last shading into a gray. The

black center is first pasted upon a manilla board with *good library* paste, and then the board is attached to the tablet by simply gumming the *edges* with a thin solution of Le Page's glue poisoned with corrosive sublimate to keep insects away. At this point the tablet must be placed under a press to dry, in order to avoid warping. The writer has used thin sheets of lead for this purpose, which have been very successful.

After drying for three or four hours the tablet is ready for the labels and specimens ; the former being printed upon the same stock as the tablet cover, and attached by putting a few drops of glue upon the ends and in the middle, and placed under a press for an hour or so. For order, class, family, etc., a tablet 3×1 inch has been adopted and the printed label glued to it. For genera a tablet $3 \times \frac{1}{2}$ inch has been found desirable. The tablets have been graded in the following sizes, the unit width being three inches : 3×2, 3×4, 3×6, 3×9, 6×6, 9×9. These sizes will accommodate any specimens save those which should be placed in special upright cases. The larger tablets, 6×6 and 9×9, will need to have a piece of heavy paper pasted on the reverse side, to keep them from warping. The specimens are attached to the tablets with Le Page's glue.

The expense of these tablets will not exceed one and a half cents each, and several hundred can be manufactured in a day. A case installed in this manner presents a handsome appearance and greatly increases the facility for examination.

It has been urged by some that the tray is better adapted to museum purposes than the tablet, on account of the danger of mixing species. In answer to this the writer would say that the collections of the Chicago Academy of Sciences have been mounted upon tablets for the past six years, and up to the present time no mixing has taken place. Of course care must be used, with the tray equally as with the tablets, to guard against accidents. The new tablet spoken of above has been in use in the institution mentioned for the past five months.

THE LOWER AND MIDDLE SONORAN ZONES IN ARIZONA AND NEW MEXICO.

T. D. A. COCKERELL.

For some years it has been a matter of controversy whether the Mesilla Valley (3800 ft. altitude) in New Mexico should be regarded as Lower Sonoran. The present writer classed it as Upper Sonoran, and later placed it in an intermediate zone, which he proposed to call Middle Sonoran. Dr. C. H. Merriam, on the other hand, regarded it as true Lower Sonoran, and so mapped it.

The writer, unfortunately, had never been able to study the true Lower Sonoran until his visit to Phœnix last year. This visit, while undertaken for other purposes, enabled him to reach some new conclusions, which are here set forth. While the discussion is largely technical, it is hoped that it will arouse some general interest, as the conclusions reached are of practical as well as theoretical interest.

We have in New Mexico and Arizona a number of fertile valleys, of which the Salt River and Mesilla Valleys are perhaps the most important. The Salt River Valley, in particular, is said to export more fruit than all the rest of Arizona combined. Now these valleys, between them, have to supply certain markets, and it is of the highest importance to each one that it should produce that which grows to a reasonable degree of perfection and finds a ready sale. If the valleys all belong in the same zone, they may be expected, speaking broadly, to produce the same crops, and it may be that in so doing they will overstock the market. But if there is in reality a great diversity in the agricultural conditions of the several valleys, so that they not only differ in detail but belong to different life zones, — this is a fact of the utmost practical importance, since it indicates that there may be such diversity in products as almost to avoid injurious competition. More-

over, if this diversity exists, it is of great value to the ranchman or orchardist to be made aware of it, since he will not then waste time and money by setting out plants which cannot be expected to succeed.

As a matter of fact, such problems as these have already been largely solved in the cultivated areas, by the experience — often tedious and expensive — of the residents. But they have not been solved for the areas which may yet be brought under cultivation, nor are the facts sufficiently accessible to residents in other states who expect to locate in the arid west. Yet again, even those residents who are satisfied with what their own locality will produce, are usually not acquainted with the possibilities of other districts, possibilities which affect them in so far as they affect the markets.

Last spring the writer had the pleasure of meeting Dr. Merriam at Washington, and at his suggestion made for him a list of the commoner trees and shrubs of the Mesilla Valley. Dr. Merriam, glancing over this, at once said: "With possibly one or two exceptions, these are *all* Lower Sonoran types." My investigations in the Salt River Valley have convinced me of the justice of this statement, and it may be said at once that, so far as the native flora is concerned, the Mesilla and Salt River Valleys may very well be placed in the same zone. The illustrative data given further on suggest more precisely the actual condition of affairs. Many of the plants which are abundant and conspicuous in the landscape are entirely the same, while others are so similar that they may be held to indicate rather the fact that we are three hundred and odd miles to the west of the New Mexico Valley than in a different life zone. In the list of insects common to the two valleys, also, we find many of the characteristic Mesilla Valley types, described as new from thence in recent years. The absolute differences, discussed under headings 3 to 5, are important in their way, and doubtless will be emphasized by further research; but it is at least questionable whether they indicate a different life zone, or, rather, whether they would indicate one if no other facts supported the division.

Turning now to the cultivated products, the conditions are

entirely different. The contrast, instead of being weak, is of the strongest possible kind; and if the valleys compared are not in different zones, then life zones have no meaning for the horticulturist. We thus arrive at this conclusion :

In the arid west the influences of temperature upon the cultivated, irrigated plants, derived from moister regions, are very much greater than upon the native plants or animals, which have become so adapted that they endure without harm enormous variations of heat and cold.

Hence it results that from the horticulturist's standpoint, the Middle Sonoran zone is a very real division, and belongs rather with the Upper than the Lower Sonoran. We may almost define the Middle Sonoran as a zone having the cultivated products of the Upper Sonoran and the native products of the Lower.

It will of course be understood that the data here given are only illustrative, and the time is not ripe for statistical tables. It will be a matter for future research to determine the exact details of the differences between the two zones. It is reasonably to be expected, however, that we may by patient study find native species of plants and insects which afford reasonably close indications of the horticultural zones, and thus enable us to decide the zonal position in advance of cultivation. Such decisions will be greatly assisted when we are in possession of more precise meteorological data, but unfortunately we know too little at present about the daily variations of temperature in the several localities where weather observations have been made, and the differences between the temperatures of adjacent localities.

Although Tucson is considerably higher than Phœnix, it is undoubtedly Lower, as distinguished from Middle, Sonoran. Oleanders, olives, Washingtonia and date palms, pepper trees, and a cultivated Parkinsonia were seen there; and Professor Toumey tells me there is a "hot pocket" some fourteen miles to the east, where orange trees are growing.

One circumstance which artificially emphasizes the horticultural distinction between the Mesilla and Salt River Valleys is, that in the latter it is possible to irrigate the higher levels at the side of the valley, while in the former only the bottom

CULTIVATED PLANTS OF SALT RIVER VALLEY AND THE MESILLA VALLEY.

PLANT.	SALT RIVER VALLEY. (Minimum winter temperature, 32.2° F.[1])	MESILLA VALLEY. (Minimum winter temperature, 9° F.)
Date palm.	Does well.	Cannot stand the winter cold.
Washingtonia palm.	ditto.	ditto.
Olive.	ditto.	ditto.
Orange.	Does well at the sides of the valley.	ditto.
Almond.	Will bear a good crop if protected by smudges.	Cannot escape the frost in spring.
Peach.	Does well.	Does well.
Pear.	ditto.	ditto.
Apple.	Climate too hot and dry in summer.	ditto.
Fig.	Tree grows well without protection, but not successful as a crop on account of the dryness.	Killed to the ground in exposed places; grows well and fruits abundantly when protected by four walls.
Pomegranate.	Does well; much used for hedges.	Small plants growing in protected situations.
Grape.	Raisin and wine grapes do well.	Wine grapes do well.
Oleander.	Does well.	Winter too cold.
Pepper tree (*Schinus*).	ditto.	Not tried; winter doubtless too cold.
Sorghum.	ditto.	Does well.
Alfalfa.	Does well, but summers rather too hot and dry.	Grows to perfection.
Sugar beet.	Can be grown in the cool part of the year, Feb.–May.	Summers probably too hot for best results; Feb.–May too cold.
Irish potato.	Can be grown fairly well from Feb.–May.	Summers too hot; Feb.–May too cold.

lands are under ditch. In the cold weather the cold air settles in the lower lands, leaving the sides of the valley relatively warm, and hence it is that oranges can be cultivated with great success in the region about Ingleside, while they do not suc-

[1] From the observations made by Mr. W. G. Burns of the Weather Bureau at Phœnix it appears that the lowest temperature at that place in January, 1900, was 34° F., but on Feb. 7, 1899, the mercury fell as low as 24° F.

ceed commercially at Phœnix. The Larrea in the Mesilla Valley occupies only the higher levels, its lower limit, a little distance from the valley bottom, being as clean-cut as if it had been planted. But in the Salt River Valley the Larrea covers the whole area, and grows to a great size in the bottom lands, which are never so cold as to injure it. It is the desert land, once occupied by the Larrea, which has under irrigation been converted into the most flourishing orchards ; and could the Larrea land of the Mesilla Valley be irrigated the results would doubtless be most gratifying.

These examples show us the value, on the one hand, of an exact knowledge of temperature conditions; and the fallacy, on the other, of mapping the temperature for the entire country from the observations made in a few widely scattered localities. Thus the temperature tables for Phœnix would not apply to Ingleside, nor those for Mesilla Park to the bench a couple of miles away. The writer has discussed the subject from his own standpoint, that of the fauna and flora ; but he would not be understood to undervalue in any degree the knowledge of temperature in mapping life zones; all he would urge is, that for the proper mapping of zones on the temperature basis, we need a mass of information we do not possess, and are not likely to possess in the near future.

Representative Facts Regarding the Native Fauna and Flora.

(*1*) *Species Common to the Mesilla Valley and Salt River Valley.*

Plants.

Perezia nana Gray.
Pluchea (*Tessaria*) *borealis* Gray.
Pectis papposa Harv, and Gray.
Aster spinosus Benth.
Helianthus annuus L.
Baccharis glutinosa Pers.
Verbesina encelioides (Cav.) Gray.
Larrea tridentata DC.
Cladothrix lanuginosa Nutt.
Hoffmanseggia stricta Benth.
Populus fremonti Wats.
Salix fluviatilis Nutt.
Atriplex canescens (Pursh) James.
Datura meteloides DC.

No attempt was made to catalogue the flora. The plants above cited are merely some of those which are so abundant and conspicuous as to give a character to the landscape.

Besides the identical species of Baccharis and Atriplex, the Salt River Valley has another Baccharis and two other species of shrubby Atriplex not found in the Mesilla Valley.

It seemed to me that the cottonwoods (*Populus fremonti*) of the Salt River Valley were not perfectly identical with those of the Mesilla Valley, but the species is presumed to be the same.

INSECTS.

Colias eurytheme Boisd.
Pyrameis cardui (L.).
Lycæna exilis Boisd.
Libythea bachmani carinenta (Cram.).
Synchloë lacinia Geyer (larvæ on Xanthium and sunflower).
Heliothis armiger Hubn. (Buckeye).
Asphondylia neomexicana (Ckll.).
A. atriplicis (Towns).*
Diplosis atriplicicola Ckll.*
Chilocorus cacti (L.).
Drosophila ampelophila Loew.
Dorymyrmex pyramicus Rog. (Buckeye).
Hesperotettix viridis (Thos.).
Sphærophthalma donæ-anæ Ckll. and Fox.*
S. foxi Ckll.
Coleophora suædicola Ckll. (Tempe).*
Eromene (*Euchromius*) *ocellea* (Haw.) Zell. (Buckeye).
Megilla maculata (De Geer).
Aphalara suædæ, Schwarz. MS. (Tempe).
Allorhina mutabilis Gory.
Microcentrum retinervis Burm.
Dicraneura cockerelli Gill.*
Stictocephala festina Say.
Eriococcus tinsleyi Ckll. (leaf-form).*
Phenacoccus helianthi Ckll.*
Calliopsis coloradensis coloratipes (Ckll.).
Perdita asteris Ckll.*
P. salicis Ckll.
Exomalopsis solani Ckll. (Tempe).*
Agapostemon melliventris Cress. (Tempe).
Halictus pseudotegularis Ckll.
H. meliloti Ckll.*
Prosapis mesillæ Ckll. *
Mellisodes agilis Cress.
Cockerellia albipennis helianthi (Ckll.).*
Aspidiotus juglans-regiæ albus Ckll.*
Hormilia elegans Scudder.*

The species and varieties marked with an asterisk were originally described from Mesilla Valley specimens.

I have included some species found at Buckeye, as, although this is not actually in the Salt River Valley, it is virtually part of the same region.

(2) *Representative Species similar to, but not identical with, those of the Mesilla Valley.*

PLANTS.

Sphæralcea variabilis n. sp. — The common perennial Sphæralcea of the Salt River Valley, which at first sight might be taken for *S. lobata* Wooton, equally common in the Mesilla Valley. The leaves vary from 1¼ to over 3 inches long, and resemble in shape those of lobata, being quite long, with obtuse lateral lobes; but they average broader, are somewhat more regularly and finely crenulate, or the margins almost entire, and the living leaves have the surface, and especially the margins, much more wrinkled. The difference between the plants, as seen living, is sufficient to strike the eye, but it is a difference in average rather than absolute characters. There is, however, one character of greater value; the carpels of lobata are conspicuously cuspidate, whereas in variabilis they are rounded at the top, and bear no cusps. It may therefore be said that variabilis resembles lobata in its leaves, but angustifolia rather in its fruit. The basal portion of the carpels is very strongly reticulated, as in lobata. The flowers are as in lobata. This plant is here called a species, being about as distinct as the other members of its series — angustifolia, lobata, and fendleri; but it would be possible to regard variabilis as a race of lobata, or both as races of fendleri.

S. variabilis was found freely blooming about Phœnix in October. It is not so tall a plant, on the average, as *S. lobata.*

Isocoma acradenia (Greene) Greene. — This is the common Bigelovia of the vicinity of Phœnix, exactly occupying the place taken in the Mesilla Valley by *I. heterophylla wrightii.* I had confused the Phœnix plant with *I. hartwegi*, but I found the real hartwegi (certified as such by Dr. Greene) abundant at Tucson, taking the place of acradenia. *I. acradenia* has the flowers of hartwegi, with the foliage (only smaller) of heterophylla wrightii.

Cucurbita palmata Watson. — Common in the Salt River Valley, taking the place of the Mesilla Valley *C. fœtidissima.*

Prosopis velutina Wooton. — The mesquite of Arizona, found at Phœnix, Mesa, Buckeye, Tucson, etc., is distinct from *P. glandulosa* Torrey, the mesquite of the Mesilla Valley.

Acacia greggii Gray. — Abundant in the Salt River Valley; much larger than the species of the Mesilla Valley.

Echinocactus lecontei (Engelm.) Toumey. — This barrel cactus takes the place of the Mesilla Valley *E. wislizeni* Engelm.; the latter, however, occurs at Tucson. *E. lecontei* is usually considered a variety of *E. wislizeni*, but when I saw it, it seemed to me distinct, and Professor Toumey tells me that it is a valid species.

Kallstræmia grandiflora Torrey. — Very abundant in Phœnix; a very beautiful flower, which ought to be in cultivation. It is allied to the much less conspicuous *K. brachystylis* Vail. of the Mesilla Valley.

K. grandiflora arizonica Ckll., with much smaller flowers and much shorter flower stalks, is also common at Phœnix.

K. californica (Wats.) Vail. det. Wooton, was found near Buckeye. It has never been seen in the Mesilla Valley.

Croton sp. — The common Croton of the Mesilla Valley is *C. neomexicanus*. At Phœnix I found in its stead a tall species closely allied to *C. texensis*, but less leafy at the top, and with very much denser pubescence on the leaves. No description has been found to fit it, and it may be undescribed.

Lycium gracilipes Gray. — Abundant in the Salt River Valley, taking the place of the Mesilla Valley *L. torreyi*.

INSECTS.

Sphærophthalma gloriosa (Sauss.) takes the place in the Salt River Valley of *S. pseudopappus* in the Mesilla Valley. This is a so-called "velvet-ant," covered with long white hairs.

(*3*) *Species entirely different from those of the Mesilla Valley.*

PLANTS.

Cereus giganteus Engelm. — The giant cactus.

Holacantha emoryi Gray. — The crown of thorns.

Parkinsonia torreyana Wats. and *P. microphylla* Torrey. — The two species of palo verde.

Hetherotheca subaxillaris (Lam.) B. and R. — A yellow flowered composite, very abundant throughout the Salt River Valley. It is doubtless native, as I found two new bees (*Perdita mellina* Ckll. and *P. heterothecæ* Ckll.) specially attached to it.

The above are conspicuous in the landscape; no attempt was made to catalogue the less conspicuous forms.

SCALE INSECTS.

It is an interesting fact that allied or identical plants in the two regions under consideration are in certain cases infested by entirely different scale-insects. Thus:

The Larrea in the Salt River Valley is infested by *Dactylopius irishi* Ckll. and *Tachardia larreæ* Comst., while the same plant in the Mesilla Valley produces *Dactylopius steelii* Ckll. and Towns., *Icerya rileyi* Ckll. and *Eriococcus larreæ* Parrott and Ckll.

The mesquite (*Prosopis velutina*) in the Salt River Valley is infested by *Xerophilaspis prosopidis* Ckll. and *Diaspis arizonicus* Ckll.; at

Tucson it produces *Aspidiotus candidulus* Ckll., *Toumeyella mirabilis* Ckll., *Eriococcus quercus toumeyi* Ckll. and the Xerophilaspsis. The mesquite (*Prosopis glandulosa*) of the Mesilla Valley produces *Icerya rileyi* Ckll. and *Dactylopius prosopidis* Ckll. The mesquite (*Prosopis juliflora*) of Jamaica produces *Icerya rosæ* R. and H. and *Dactylopius virgatus* Ckll.

(*4*) *Species of the Mesilla Valley absent from the Salt River Valley.*

A curious case is that of the mistletoe of the cottonwood, *Phoradendron macrophyllum* (*Phoradendron flavescens* var. *macrophyllum* Engelm., *Bot. Wheeler Surv.*, p. 252) which is abundant and destructive on the *Populus fremonti* of the Mesilla Valley, but does not go up the valley of the Rio Grande as far as its host, or down into the Salt River Valley, where the same cottonwood abounds. It is not that it is absent from the Gila basin, for it was first described from the Gila and Bonita Rivers. Its absence from the Salt River Valley is confirmed by Professor McClatchie; and, indeed, were it present it could not escape observation.

The bag-worm (*Oiketicus townsendi*) of the Mesilla Valley, although common at Tucson, was not observed in Salt River Valley.

(*5*) *Ants of Buckeye and the Mesilla Valley.*

A series of ants collected at Buckeye was kindly determined for me by Mr. Ernest André, and it appears that the ant-fauna of this region has little in common with that of the Mesilla Valley, as witness the accompanying lists :

MESILLA VALLEY.

Camponotus maculatus maccooki Forel.
C. marginatus decipiens Emery.
Formica subsericea subpolita Mayr.
Forelius maccooki Forel.
Lasius umbratus bicornis Foerst.
Dorymyrmex pyramicus Rog.
Aphænogaster albisetosa Mayr.
A. cockerelli André.
Tapinoma anale André.
T. sessile Say.
Atta (*Trachymyrmex*) n. sp.?
Pogonomyrmex barbatus Sm. (race *fuscatus*).
P. badius Latr.
P. californicus Buckl.
Monomorium minutum Mayr.
M. pharaonis L.
Pheidole morrisi Forel.
Solenopsis geminata Fabr.
Cremastogaster læviuscula clara Mayr.
Labidus harrisii (Hald.).

BUCKEYE.

Atta versicolor Perg.
Cremastogaster atra Mayr.
Aphænogaster pergandei Mayr.
Dorymyrmex pyramicus Rog.
Prenolepis vividula guatemalensis Forel.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES. VIII.

THE ISOPODA. — PART II.

ASELLOTA, ONISCOIDEA, EPICARIDEA.

HARRIET RICHARDSON.

IN addition to the references to the literature already given in Part I of the Synopsis of the Isopoda is the following list of papers pertaining especially to the fresh-water forms.

1871. PACKARD, A. S. The Mammoth Cave and its Inhabitants. *Amer. Nat.* Vol. v, p. 751.

1874. SMITH, S. I. The Crustacea of the Fresh Waters of the United States. *Rept. U. S. Fish Comm. for 1872–1873.* Pp. 657–661.

1876. FORBES, S. A. List of Illinois Crustacea, with Descriptions of New Species. *Bull. Ill. State Lab.* N. H., No. 1, pp. 8–13.

1876. HARGER, OSCAR. Description of Mancasellus brachyurus, a New Fresh-Water Isopod. *Amer. Journ. Sci.* (3). Vol. xi, pp. 304, 305.

1881. PACKARD, A. S., and COPE, E. D. The Fauna of Nickajack Cave. *Amer. Nat.* Vol. xv, pp. 879–880.

1890. GARMAN, H. A New Fresh-Water Crustacean. *Bull. Essex Institute.* Vol. xxii, pp. 28–30.

1899. HAY, W. P. Description of a New Species of Subterranean Isopod. *Proc. U. S. Nat. Mus.* Vol. xxi, pp. 871, 872.

SYNOPSIS OF THE ISOPODA (*continued*).

IV. ASELLOTA.

a. Eyes generally present. First pair of legs prehensile or subcheliform. Last three pairs of legs ambulatory, not natatory.

b. Three posterior segments of thorax not sharply marked off from the four anterior ones, and not smaller. Caudal segment large, shield-like. Eyes, when present, lateral or subdorsal, not placed on peduncle-like projections of the head. Superior antennæ issuing close together. Legs subequal in length.

c. Lateral parts of head scarcely expanded. Eyes, when present, small, lateral. Peduncle of inferior antennæ without small accessory appendage outside of third joint. Legs ambulatory, except first pair, which are distinctly subcheliform; legs with dactylus generally uniunguiculate. First pair of pleopoda in female very small, not operculiform. Outer lamella of second pair very large and incrusted, so as to form, together with the corresponding lamellæ of the other side, a sort of operculum, covering the two succeeding pairs.

Family XV. Asellidæ

c'. Lateral parts of head lamellarly expanded. Eyes, when present, usually subdorsal. Peduncle of inferior antennæ generally with small accessory appendage outside of third joint. Legs ambulatory, except first pair, which are sometimes prehensile; legs with dactylus generally bi- or tri-unguiculate. First pair of pleopoda in female transformed into a single, large operculum. Outer lamellæ of two succeeding pairs narrow and confluent with basal part . . . . Family XVI. Janiridæ

b'. Three posterior segments of thorax, as a rule, sharply marked off from four anterior ones, and much smaller. Caudal segment more or less vaulted above, subpyriform. Eyes, when present, placed on the tips of lateral peduncle-like projections of the head. Superior antennæ placed widely apart. First pair of legs much shorter than others. Succeeding pairs more or less rapidly increasing in length . . . . . Family XVII. Munnidæ

a'. Eyes wanting. First pair of legs subprehensile. Last three pairs of legs natatory, with some joints flattened and ciliated. First pair of legs shorter than three following pairs. Second, third, and fourth pairs very elongate . . . . . Family XVIII. Munnopsidæ

FAMILY XV. ASELLIDÆ (FRESH-WATER ISOPODA).

a. Mandibles without a palp. Last six pairs of legs with dactylus biunguiculate . . . . . Mancasellus Harger

a'. Mandibles with a three-jointed palp. Last six pairs of legs uniunguiculate.

b. Eyes present. Body oblong, depressed. Head small, narrower and shorter than first thoracic segment. Caudal segment not longer than broad . . . . . Asellus Geoffroy

b'. Eyes wanting. Body elongate, narrow. Head large, not narrower than first thoracic segment, and longer. Caudal segment much longer than broad . . . . . Cæcidotea Packard

Genus Mancasellus Harger.

a. Lateral margins of head entire.

Mancasellus brachyurus Harger, Virginia

a'. Lateral margins of head not entire.

b. Lateral margins of the head with a deep cleft on either side.

Mancasellus macrourus Garman, Ky., Tenn.

b'. Lateral margins of the head with a large rounded sinus on each side in the middle.

c. External antennæ as long or longer than the body.

Mancasellus lineatus (Say), South Carolina

c'. External antennæ half as long as the body.

Mancasellus tenax Harger, Lake Superior

Genus Asellus Geoffroy.

a. Caudal stylets, or uropoda longer than terminal abdominal segment. Post-lateral margins of head without spines.

b. Caudal stylets broad and flattened. Propodus of first pair of legs much enlarged and subglobular, with a prominent acute tooth about, or a little above, the middle, and a lobe bearing one or two acute teeth near the base on its palmar margin.

Asellus communis Say, Conn., Penn., Ind., Ill., Mich., Miss.

b'. Caudal stylets extremely narrow and cylindrical. Propodus of first pair of legs narrow, elongate, without prominent acute teeth on its palmar margin.

Asellus attenuatus Richardson, Virginia

a'. Caudal stylets shorter than terminal abdominal segment. Post-lateral margins of head produced into prominent lobes bearing spines.

b. Post-lateral lobes bearing each several stout spines. Lateral margins of all the thoracic segments except the first with no emargination. Flagellum of first pair of antennæ consists of eleven to thirteen joints. Caudal stylets broad and flat, half as long as terminal abdominal segment . . . *Asellus brevicauda* Forbes, Illinois

b'. Post-lateral lobes bearing each a single spine. Lateral margins of all the thoracic segments except the first distinctly emarginate. Flagellum of first pair of antennæ consists of nine joints. Caudal stylets broad and flat, but narrower than in *A. brevicauda*, and three-fifths as long as terminal abdominal segment

Asellus intermedius Forbes, Illinois

Asellus tomalensis Harford, California

The description of this form is so meagre and insufficient that it is impossible to place it in the key with the other species of Asellus.

Genus Cæcidotea Packard.

a. Caudal stylets nearly half as long as body; basal joint or peduncle nearly twice as long as inner ramus; outer ramus from one-third to one-half as long as inner branch. First pair of antennæ short, reaching but little beyond the second joint of the second pair of antennæ.

Cæcidotea stygia Packard, Ind., Ill., Ky.

a'. Caudal stylets no longer than terminal abdominal segment; basal joint or peduncle shorter than inner ramus; outer ramus most as long as

inner branch. First pair of antennæ long, reaching to the end of the third joint of the second pair of antennæ, and being nearly twice as long as those of *C. stygia*.

Cæcidotea nickajackensis Packard, Tennessee

FAMILY XVI. JANIRIDÆ.

a. Eyes dorsal. Antennæ of the first pair well developed, with multi-articulate flagellum, or with flagellum rudimentary. Antennæ of the second pair long, with multi-articulate flagellum; peduncular joints not dilated. Mandibles with a three-jointed palp, and with cutting part separated from molar part by a deep incision.

b. Head without any true rostrum. First pair of antennæ extremely small, with flagellum rudimentary. Second pair of antennæ of moderate length, without any distinctly squamiform appendage. First pair of legs not prehensile. Uropoda extremely small, branches very short, nodiform . . . . . Jæra Leach

b'. Head with prominent rostral projection, obtuse in front, or with a comparatively short rostral projection. First pair of antennæ well developed; flagellum multi-articulate. Second pair of antennæ very much elongated, with a well-marked, scale-like appendage outside of third joint. First pair of legs prehensile. Uropoda largely developed, with branches slightly unequal.

c. Head with lateral parts produced to very prominent acute lappets. Segments of thorax with lateral parts laciniate and produced. Caudal segment forming on each side, at the end, a triangular expansion . . . . . Ianthe Bovallius

c'. Head with lateral parts not produced into lappets. Segments of thorax with lateral parts not produced, not laciniate. Caudal segment rounded, not expanded laterally . . Janira Leach

a'. Eyes lateral. Antennæ of the first pair small, with flagellum obsolete. Antennæ of the second pair short, with peduncular joints dilated, rudimentary flagellum composed of five articles, and equal in length to the width of the head. Mandibles with a three-jointed palp, and with cutting part composed of five teeth . . . Jæropsis Koehler

Genus Jæra Leach.

a. Anterior margin of the head broadly excavated on each side over the bases of the antennæ. Extremity of terminal segment notched for the insertion of the uropoda, the median point being almost imperceptible . . . . . *Jæra marina* (Fabricius), *N*, surface

a'. Anterior margin of the head nearly straight. Extremity of terminal segment with a double excavation, the median point reaching the extremity of the sides . . . . *Jæra wakishiana* Spence-Bate, *A*

Genus Ianthe Bovallius.

a. Head with prominent rostrum.

b. Lateral margins of head produced into two angulations. Terminal segment of the body, with central posterior portion acute, triangular. Epimera evident . . *Ianthe triangulata* Richardson, *D*

b'. Lateral margins of the head produced in one anterior angulation. Terminal segment of the body, with central posterior portion nearly straight, rounded. Epimera not evident.

c. Rostrum as long as the head. Flagellum of first pair of antennæ 12-articulated, shorter than the breadth of the head. Flagellum of second pair of antennæ 50-articulated. First thoracic segment shorter than second. Second and third segments equal, and longest, much longer than seventh. Terminal segment smooth on dorsal side, without spine-like tubercle. Peduncles of uropoda longer than postero-lateral angulations of terminal segment. *Ianthe spinosa* (Harger), *N*, 80–100 fms.

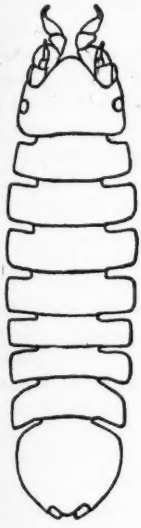


Fig. 12.—Jæropsis lobata.

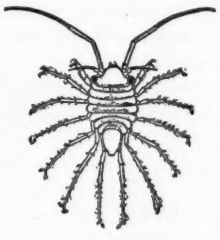


Fig. 13.—Munna fabricii.

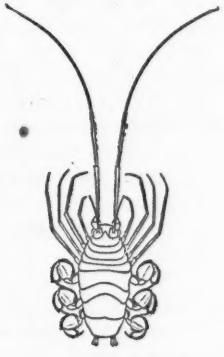


Fig. 14.—Eurycope cornuta.

c'. Rostrum much longer than head. Flagellum ot first pair of antennæ 60–70-articulated, nearly as long as the breadth of the head. Flagellum of second pair of antennæ 280-articulated. First thoracic segment as long as second. Seventh segment longest. Terminal segment of body, with a single spine-like tubercle on its dorsal side. Peduncle of uropoda shorter than postero-lateral angulations of terminal segment of body . . . . . *Ianthe speciosa* Bovallius, *N*

a'. Head without rostrum, in place of which is small median point. *Ianthe erostrata* Richardson, *A*

Genus Janira Leach.

a. Anterior margin of the head straight. *Janira maculosa* Leach, *N*, 100–116 fms.

a'. Anterior margin of the head not straight.

b. Front of head three-lobed, the center lobe subacute, rather longer than others, but not rostrate . . *Janira occidentalis* Walker, *P*

b'. Front of head produced in the middle in a short, sharp rostrum, and the antero-lateral angles of head also produced.

c. Antero-lateral angles of head sharp. Lateral margins of first four thoracic segments obtusely incised, each showing two broad angulations. Uropoda of female shorter than half the terminal segment; those of male as long as terminal segment of body . . . . *Janira tricornis* (Krøyer), *N*, 5–50 fms.

c'. Antero-lateral angles of the head shorter and less sharp. Margins of the first thoracic segment rounded, not emarginate. Uropoda alike in the two sexes, and as long as the terminal segment of the body.

Janira alta (Stimpson), *N*, 35–300 fms.

Genus Jæropsis Koehler . . . . . *Jæropsis lobata* Richardson, *D*

FAMILY XVII. MUNNIDÆ.

Genus Munna Krøyer.

a. Caudal segment, with lateral edges evenly convex, and each armed with a single slender denticle; apical lamellæ distinctly serrated. Eyes large. Superior antennæ, with flagellum composed of four joints, including very small apical joint. Flagellum of inferior antennæ longer than peduncle. Last pair of legs scarcely longer than body. Legs slender. Uropoda obliquely truncate at tip.

Munna fabricii Krøyer, *N*, 12–200 fms.

a'. Caudal segment, with lateral edges rather bulging in front, and each armed with four strong denticles; without any serrulated lamellæ. Eyes small. Superior antennæ, with flagellum composed of three articulations, including very small apical joint. Flagellum of inferior antennæ not attaining the length of the peduncle. Last pair of legs scarcely longer than anterior division of body. Legs shorter and stouter than usual. Uropoda produced at tip into several dentiform projections, one of which is hook-like.

Munna krøyeri Goodsir, *N*, 10–60 fms.

FAMILY XVIII. MUNNOPSIDÆ.

a. Head of moderate size, deeply emarginate on each side for the insertion of the antennæ; frontal part produced. First four thoracic segments transversely excavated dorsally. Superior antennæ, with flagellum multi-articulate. Natatory legs of the same structure, carpal joint foliaceous.

b. Body, with anterior division much broader than posterior; three posterior segments densely crowded together. Caudal segment

oblong-oval. Mandibles without any molar expansion; cutting edge but slightly dentated. First two pairs of legs of same structure, though somewhat different in size; two succeeding pairs elongated. Dactylus wanting on natatory legs. Uropoda simple, biarticulate . . . . . Munnopsis M. Sars

b'. Body, with anterior division less sharply marked off from posterior; three posterior segments very large and broad. Caudal segment semioval. Mandibles with molar expansion; cutting edge divided into strong teeth. First pair of legs shorter than three succeeding pairs, which are subequal in length, and very much elongated. Dactylus distinct on natatory legs. Uropoda biramous, branches single-jointed . . . . . Eurycope G. O. Sars

a'. Head very large and broad, transversely truncated in front, lateral parts greatly expanded. First four thoracic segments slightly excavated transversely. Superior antennæ, with flagellum not much elongated. First two pairs of natatory legs of similar structure, carpal joint large and expanded, cordiform; last pair much narrower than two succeeding pairs, carpal joint but slightly expanded. Caudal segment triangular in form . . . . . Ilyarachna G. O. Sars

Genus Munnopsis M. Sars . *Munnopsis typica* M. Sars, *N*, 20–122 fms.

Genus Eurycope G. O. Sars.

Eurycope cornuta G. O. Sars, *N*, 119–220 fms.

Genus Ilyarachna G. O. Sars.

Ilyarachna hirticeps G. O. Sars, *N*, 100–227 fms.

V. Oniscoidea (Terrestrial Isopoda).

a. Buccal mass not very prominent below. First maxillæ, with two plumose setæ on the inner plate. Mandibles with molar expansion obsolete, without any triturating surface, it being replaced by brush-like recurved setæ.

b. External antennæ generally long, close together, with antennal openings large. Body, as a rule, scarcely able to be contracted into a ball. Head less manifestly immersed in first thoracic segment. Lateral parts of the head separated by a vertical marginal and infra-marginal line. Clypeus arched. Legs generally long. Uropoda produced, reaching beyond the terminal segment of the abdomen and the preceding segment. Terminal segment narrower than preceding ones and conically produced at end.

Family XIX. Oniscidæ

b'. External antennæ generally short, with antennal openings small. Body able to be contracted into a ball. Head immersed in first thoracic segment. Lateral parts of the head undifferentiated. Clypeus perpendicular. Legs generally short. Uropoda short, flattened, not reaching beyond the terminal segment of the

abdomen or the preceding segment. Terminal segment short and broad . . . . . Family XX. Armadillididæ

a'. Buccal mass prominent. First maxillæ with three plumose setæ on the inner plate. Mandibles with molar expansion large and broad, exhibiting a finely fluted triturating surface.

b. Head without any lateral lobes, frontal part rounded. Eyes well developed or wanting. Inner antennæ with last joint very small, and without distinctly developed sensory filaments. Posterior maxillæ with two thick hairy bristles. Maxillipeds with terminal part distinctly five-articulate, masticatory lobe truncate at tip, epignath short. External sexual appendages in male double. Inner branches of first pair of pleopoda of a similar structure in both sexes, that of second pair in male terminating in a long stylet. Both branches of uropoda styliform.

Family XXI. Ligiidæ

b'. Head with distinct, though not very large lateral lobes, front more or less produced. Eyes small or wanting. Inner antennæ with last joint well developed and tipped with a number of delicate sensory filaments. Posterior maxillæ without any bristles. Maxillipeds with terminal part generally imperfectly articulated, masticatory lobe terminating in a thin lash, epignath narrow, linguiform. Sexual appendage of male simple; inner branch of both first and second pairs of pleopoda transformed for copulative purposes. Uropoda with branches conically tapered.

Family XXII. Trichoniscidæ

FAMILY XIX. ONISCIDÆ.

a. Flagellum of external antennæ biarticulate. External opercular ramus of the first, second, and rarely of the third, or all the pairs of abdominal appendages furnished with tracheæ.

b. Abdomen abruptly narrower than thorax. Epimera of all the abdominal segments small, subappressed.

Metoponorthus Budde-Lund

b'. Abdomen not abruptly narrower than thorax. Epimera of all the abdominal segments large, prominent, well developed.

c. Body very convex, capable of being rolled up into a perfect ball. Joints of the flagellum of the external antennæ subequal. Last abdominal segment reaching very little beyond the epimera of the preceding segment. External branches of the uropoda equal in both sexes. External opercular branch of all the abdominal appendages furnished with tracheæ.

Cylisticus Schnitzler

c'. Body more or less depressed, with lateral parts lamellarly expanded. Joints of the flagellum of the external antennæ with

the first joint generally longer than the second, often subequal, or even a little shorter. Last abdominal segment generally not reaching beyond the epimera of the preceding segment. External branches of the uropoda longer in the male than in the female. External opercular branch of the first and second pairs of abdominal appendages, and, in some of the species, of all the pairs, furnished with tracheæ . . . Porcellio Latreille

a'. Flagellum of external antennæ triarticulate. External opercular ramus of the abdominal appendages containing no special respiratory organ.

b. Front of head produced at the middle and at the sides in tubercles; lateral tubercles horn-like . . . . . Alloniscus Dana

b'. Front and sides of head not produced in tubercles. With or without lateral lobes.

c. Abdomen abruptly narrower than the thorax. Epimera of thoracic segments small. Epimera of abdominal segments very small, but manifest. External branches of the uropoda styliform . . . . . Philoscia Latreille

c'. Abdomen not abruptly narrower than thorax. Epimera of thoracic segments large. Epimera of abdominal segments large. External branches of the uropoda conical.

d. Surface of body granulated or tuberculate. Epimera of all the thoracic segments with the posterior angle acute. Basal article of the uropoda oblong, with the outer side obliquely carinated . . . . . Oniscus Linnæus

d'. Surface of body setigerous, scarcely granulated. Epimera of the first three thoracic segments with the posterior angles roundly obtuse, of the fourth segment straight, and of the other segments acute. Basal article of the uropoda short and broad, with the outer side sulcate. Lyprobius Budde-Lund

Genus Metoponorthus Budde-Lund.

a. Inner mala of the right mandible with four to five, of the left mandible with six pencils of hairs. Second and third joints of the peduncle of the second pair of antennæ furnished with a small apical tooth; first joint of flagellum much longer than second joint. No middle frontal lobe. Color brown, or reddish-brown.

Metoponorthus pruinosus Brandt, North America

a'. Inner mala of the right mandible with four, of left mandible with five pencils of hairs. Second and third joints of the peduncle of the second pair of antennæ without small apical tooth; first joint of flagellum shorter than second. Middle frontal lobe small, widely rounded. Color varying from gray to black, with three longitudinal lines of white spots . *Metoponorthus virgatus* Budde-Lund, Florida

Genus Cylisticus Schnitzler.

Cylisticus convexus De Geer, North America

Genus Porcellio Latreille.

a. Surface of body smooth.

b. Frontal median lobe of head rounded, a little produced. Articles of the flagellum of the external antennæ equal in length. Last segment of the abdomen with its extremity widely rounded.

Porcellio formosus Stuxberg, California

b'. Frontal median lobe of head more acute, minute. First article of the flagellum of external antennæ equal in length to the other, or a little longer. Last segment of the abdomen with its extremity acute . . . . . *Porcellio lævis* Latreille, North America

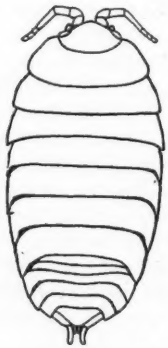


FIG. 15. — Alloniscus perconvexus.

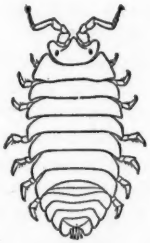


FIG. 16. — Actoniscus ellipticus.

a'. Surface of body roughly granulate or tuberculate.

b. Inner mala of the mandibles with four to five pencils of hairs. Body with spots.

c. Third joint of the peduncle of the second pair of antennæ furnished with a small apical tooth. Frontal lateral lobes of moderate size. Color varying from gray to black, with three longitudinal lines of white spots. Flagellum with joints subequal, or first shorter than second.

Porcellio rathkei Brandt, North America

c'. Second joint of the peduncle of the second pair of antennæ furnished with a large apical tooth. Frontal lateral lobes large. Color yellow; body spotted with black, spots arranged in longitudinal lines. Flagellum with first joint a little longer than second joint. *Porcellio spinicornis* Say, North America

b'. Inner mala of the right mandible with four to five pencils of hairs, of left mandible with seven to eight pencils. Body without spots. Frontal lateral lobes of head large, oblique.

Porcellio scaber Latreille, North America

Genus Alloniscus Dana.

a. Surface of body very densely granulated. Margins of epimera serrated.
Alloniscus mirabilis Stuxberg, California

a'. Surface of body punctate.

b. Lateral processes of head large, prominent.
Alloniscus cornutus Budde-Lund, California

b'. Lateral processes of the head small, scarcely prominent.
Alloniscus perconvexus Dana, Or., Cal.

Genus Philoscia Latreille.

a. Body smooth, without spines.

b. Body striped with two broad dorsal bands.
Philoscia vittata Say, North America

b'. Body not striped, but dotted with numerous spots.

c. Frontal marginal line straight. Color varying from black to brown, with white spots.
Philoscia nigricans Budde-Lund, Louisiana

c'. Frontal marginal line produced in the middle, a little arcuate. Color violet, with white spots.
Philoscia brevicornis Budde-Lund, Louisiana

a'. Body with numerous spines above . *Philoscia spinosa* Say, Georgia

Genus Oniscus Linnæus.

a. Caudal segment a little shorter than inner branch of the uropoda.
Oniscus asellus Linnæus, North America

a'. Caudal segment exactly equal to the inner branch of the uropoda.
Oniscus affinis Say, North America

Genus Lyprobius Budde-Lund.
Lyprobius pusillus Budde-Lund, California

Family XX. Armadillididæ.

a. Outer branch of the uropoda small or very small, smooth. Clypeus with the superior margin entire, lobated at the sides. First thoracic segment, often the second also, with the epimera posteriorly cleft, rarely entire. Exterior opercular branch of all the pleopoda furnished with tracheæ . . . . . Cubaris Brandt

a'. Outer branch of the uropoda large, flattened, lamellar. Clypeus with the superior margin lightly sinuated, not lobated. Epimera of the first thoracic segments simple, entire. Exterior opercular branch of the first and second pairs of pleopoda furnished with tracheæ.
Armadillidium Brandt

Genus Cubaris Brandt . . *Cubaris californica* (Budde-Lund), California
Cubaris affinis (Dana), California
Cubaris pisum (Budde-Lund), Florida

Genus Armadillidium Brandt.
Armadillidium vulgare (Latreille). North America

FAMILY XXI. LIGIIDÆ.

a. Uropoda with branches equal in length, styliform, often filiform. Interior mala of the mandibles with numerous pencils of hairs. Last segment of body broad, with distinct epimeral plates. Maxillipeds with palp 4–5-jointed; epignath rounded . . . . Ligia Fabricius

a'. Uropoda with branches unequal in length.

b. Extremity of uropoda furnished with two long apical bristles. Interior mala of the right mandible with three pencils of hairs, of the left mandible with five pencils of hairs. Last segment of body small, and without any epimeral plates. Maxillipeds with a five-jointed palp; epignath narrow, linguiform. Ligidium Brandt

b'. Extremity of uropoda not furnished with two long apical bristles. Styloniscus Dana

Genus Ligia Fabricius.

a. External antennæ shorter than the body.

b. Uropoda about equal to half the length of the body.
Ligia occidentalis Dana, *D*, Littoral

b'. Uropoda not equal to half the length of the body.

c. Uropoda equal to one-fifth the length of the body.
Ligia pallasii Brandt, *AP*, Littoral

c'. Uropoda nearly equal to one-third the length of the body.
Ligia oceanica (Linn.), *N*, Littoral

a'. External antennæ longer than body or equal to length of body. Uropoda about equal to two-thirds the length of body.
Ligia exotica Roux, *D*, Littoral

Genus Ligidium Brandt.

a. Inner process of the basal article of the uropoda three times shorter than the external terminal branch; internal terminal branch reaching the apex of the external branch; the two terminal hairs equal in length to the external branch.
Ligidium hypnorum (Cuvier), *P*, Littoral

a'. Inner process of the basal article of the uropoda four times shorter than the external terminal branch; internal terminal branch long, extending much beyond the apex of the external branch, being a sixth part longer; the two terminal hairs short, equal in length to half the external branch . . . . *Ligidium tenue* Budde-Lund, *A*, Littoral

Genus Styloniscus Dana . *Styloniscus gracilis* Dana, California, Littoral

Genus Euphiloscia Packard . . . *Euphiloscia elrodii* Packard, Indiana

This genus probably belongs here.

FAMILY XXII. TRICHONISCIDÆ.

a. Abdomen abruptly narrower than thorax. Head rounded in front, with distinct, though small lateral lobes. Terminal abdominal segment truncate at tip . . . . . Trichoniscus Brandt

a'. Abdomen not abruptly narrower than thorax.

b. Head rounded in front, not lobated at the sides. Abdominal epimera but little developed . . . . . Scyphacella Smith

b'. Head triangularly produced in front, with large lateral lobes. Abdominal epimera lamellarly expanded.

c. Body sculptured dorsally with more or less distinct longitudinal ribs. Terminal abdominal segment truncate at apex. Basal segment of the uropoda not simulating the epimera of the preceding segment. . . . . Haplophthalmus Schöbl.

c'. Body not sculptured dorsally. Terminal abdominal segment rounded posteriorly. Basal segment of the uropoda simulating the epimera of the preceding segment . Actoniscus Harger

Genus Trichoniscus Brandt.

Trichoniscus pusillus Brandt, North America at Niagara

Genus Scyphacella Smith . . . *Scyphacella arenicola* Smith, *N*, Beach

Genus Haplophthalmus Schöbl.

Haplophthalmus puteus Hay, fresh water, Indiana

Genus Actoniscus Harger . . . *Actoniscus ellipticus* Harger, *N*, Beach

VI. Epicaridea.

a. Body of female distinctly segmented, more or less asymmetrical, twisted either to right or left. Maxillipeds lamellar, biarticulate, and more frequently exhibiting a small terminal joint. Legs seven pairs, sometimes obsolete on one side. Incubatory plates five pairs, more or less arching over the ventral surface of the thorax. Pleopoda forming simple or double lamellæ, all of the same structure, rarely obsolete. Male with all the segments of the thorax sharply defined. Last larval stage with the flagellum of the antennæ 4-articulate; legs of uniform structure; uropoda with inner branch shorter than outer. Parasitic on decapodous Crustacea.

Family XXIII. Bopyridæ

a'. Body of female perfectly symmetrical, the segmentation only visible, as a rule, in the middle of the dorsal face. Maxillipeds lamellar, without any terminal joint. Only five pairs of legs present. Incubatory plates comparatively small, sometimes greatly reduced in number, and scarcely at all partaking of the formation of the marsupium, which constitutes two separate cavities, bounded by the lateral walls of the body itself. Pleopoda generally rudimentary or wholly absent. Male with head and first segment of thorax coalesced. Last larval stage with the flagellum of the antennæ 5-articulate; legs of the first pair shorter and thicker than the others; uropoda with the branches subequal. Parasitic on Schizopoda.

Family XXIV. Dajidæ

FAMILY XXIII. BOPYRIDÆ.

a. Elongated appendages attached to the sides of the thorax in the female.
  b. Branchiæ affixed to the sides of the abdomen in both sexes. Abdominal branchiæ in the male slender, cylindrical; in the female branching . . . . . Ione Latreille
  b'. Branchiæ affixed to the sides of the abdomen in the female. Abdominal branchiæ wanting in male; in female these appendages are simple sacs, not branching . . . . . Argeia Dana
a'. Thorax in female without elongated appendages.
  b. Body of female with one side greatly swollen and much longer than other. Segments of thorax only visible dorsally, coxal plates only present on shorter side. Abdomen consisting of five segments. Only first leg present on larger side, others wholly obliterated. Four pairs of pleopoda present. Male with abdominal segments fused. . . . . Phryxus Rathke
  b'. Body of female with neither side swollen. Thorax distinctly segmented. Abdomen consisting of six segments. All the legs present on both sides.
    c. Pleopoda in female obsolete, replaced by fleshy ridges. Uropoda wanting . . . . . Bopyroides Stimpson
    c'. Pleopoda in female present. Uropoda distinct.
      d. Legs of female with an adhesive process (exopod) attached to the coxal joint of the legs. This process is papillose in the first four pairs, rudimentary in the last three. Terminal joint of legs is inflated, without claw. Abdominal appendages elongated, coarsely pinnate. Cepon Duvernoy
      d'. Legs of female without exopod. Terminal joint of legs not inflated. Abdominal appendages not pinnate.
        e. Pleopoda well developed, biramous. Pseudione Kossmann
        e'. Lateral margins of abdominal segments divided by marginal furrow into superior and inferior rami; inferior rami conical, papilliform; superior rami consisting of two equal elongated lamellæ. Phyllodurus Stimpson

Genus Ione Latreille . . . . . *Ione cornuta* Spence Bate, *A*

Genus Argeia Dana.

a. Head transverse. All the thoracic appendages present. All the abdominal appendages present . . . *Argeia pugettensis* Dana, *P*

a'. Head bilobate. Thoracic branchial appendages apparently absent in some of the anterior segments. Last three pairs of abdominal appendages wanting . . . . . *Argeia depauperata* Stimpson, *P*

Genus Phryxus Rathke . . . . . *Phryxus abdominalis* (Krøyer), *N*

Genus Bopyroides Stimpson.

a. Margins of body, especially at the head, very acute and somewhat recurved. Lateral extremities of the abdominal segments sharply square-cut . . . . . *Bopyroides acutimarginata* Stimpson, *P*

a'. Margins of the body not acute . *Bopyroides hippolytes* (Krøyer), *N*

Genus Cepon Duvernoy . . . . . *Cepon distortus* Leidy, *M*

Genus Pseudione Kossmann . . . . . *Pseudione giardi* Calman, *P*

Genus Phyllodurus Stimpson . . *Phyllodurus abdominalis* Stimpson, *P*

Family XXIV. Dajidæ.

Genus Dajus Krøyer . . . . . *Dajus mysidis* Krøyer, *N*

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Annual Report of the Smithsonian Institution, 1897. — This volume contains a number of papers upon anthropological subjects, some of which have been reviewed in this journal.

"Mescal: a New Artificial Paradise" is described by Havelock Ellis from his own experience with the drug. Mescal — not to be confounded with the intoxicating drink distilled from the agave — is the blunt dried leaves of the cactus, called Anhalonium Lewinii. It is used by the Kiowa Indians and some other southwestern tribes. Though the use of mescal buttons is prohibited by the government, the practice of chewing them yet prevails among the Kiowas. "The rite usually takes place on Saturday night; the men then sit in a circle within the tent round a large camp fire, which is kept burning brightly all the time. After prayer the leader hands each man four buttons, which are slowly chewed and swallowed, and altogether about ten or twelve buttons are consumed by each man between sundown and daybreak. Throughout the night the men sit around the fire in a state of reverie, — amid continual singing and the beating of drums by attendants, — absorbed in the color visions and other manifestations of mescal intoxication, and about noon on the following day, when the effects have passed off, they get up and go about their business, without any depression or other unpleasant after effect." Mr. James Mooney called the attention of the Anthropological Society of Washington to this intoxicant in 1891. Dr. Weir Mitchell later published an account of the effects of the drug. Mr. Ellis describes the effects of mescal, especially the color visions, upon himself and also upon an artist friend.

Anthropological Notes. — Accompanying No. 4, Vol. X, of the *Bulletin of the Anthropological Society of Paris* is a list of the papers published by Dr. L. Manouvrier between 1880 and 1899. There are twenty-six titles classified as: "Scientific Philosophy"; "General Psychology"; "Reports"; "Sociology"; thirty-one as "Cerebral Anatomy and Physiology"; "Craniology"; "The Brain and

the Intelligence"; thirteen as "Evolution of the Human Species"; "Relations between the Function and the Organ"; twenty as "Ethnic Evolution"; "Ancient and Modern Races"; thirteen as "Abnormal Human Variations"; "Retrogression and Degeneration"; and twelve as "Anthropologic Technique."

In the *Bulletin de la Société d'Anthropologie de Paris*, Tome X, pp. 328–381, appears a valuable paper by M. G. M. Soularus, entitled "Recherches sur les dimensions des os et les proportions squelettiques de l'homme dans les different races." In his introduction M. Soularus reviews the history of the study of the long bones of the human skeleton from the time of White — whom he persistently calls "Witte" — to the recent investigations of Manouvrier, to whom he acknowledges his indebtedness for the idea of measuring the circumference of the bones and deriving an index by comparison with the length. One hundred and seventy-four skeletons were measured, of which thirty-four were of the white race, sixty-five of the black, thirty-two of the American, twenty-four of the yellow, and sixteen of the Malayo-Polynesian race.

The conclusions are that the femur is shortest among the Americans, and the largest among the Europeans. The average length of femur among the negroes is equal to that of the whites of North Africa. As to the yellow race, it occupies a median position between the whites and negroes. Though the femur of the Americans is the shortest, it is the largest in circumference. The European index and diameter is greater than the negro.

In the males the tibia is shortest among the yellow race and the Americans; negroes and Europeans are equal; the longest average occurs among the Polynesians. Here again the race with the shortest tibia has the bone of largest diameter.

The shortest humerus is found among the negroes, the longest among Europeans. The yellow race and the Americans have a humerus but little longer than that of the negroes. But the diameter, and hence the index, is always least in the negro group.

After comparing the individual bones of the two sexes the author arrives at the following general conclusions:

1. The average length of the bones, their circumference, and their index of section vary in each race and in each sex.

The relation of the circumference of a long bone with its length is also variable. In general, the shorter the bone the greater its relative circumference. Sexual differences are greatest in the yellow race and among Europeans, least among the Arabs and negroes.

2. The vertebral column varies equally in each race and in each sex, both in length and in diameter, as a whole and in segments. It is longest among people with short limbs, short among the negroes with long legs.

3. For each race and each sex the relation between the length of the femur plus the length of the tibia to the height of the body is determined. The importance of the index of cross-section is shown in this connection, for the stature is found to be less in the case of long bones with low indices and greater in the case of short ones with a high index than would usually be determined by the mathematical method.

"The Unity of the Human Species" is the title of a twenty-page article in which the Marquis de Nadiallac endeavors to establish the thesis that man belongs to a single species uniform in anatomical structure and in the manifestations of his intelligence. He says in conclusion: "By the side of the similarity of the anatomic structure of man in all times and of all races, I have sought to place the similarity of his genius, as proved by the identity of his conceptions. The ossuaries which contain the remains of his predecessors, the custom of coloring his bones red after they have been denuded of their flesh, the mysterious symbol to which we have given the name Swastika, and other conceptions, other almost universal creations, which it would be easy to add, all tend toward the confirmation of the knowledge given to us by the earliest arms, the first tools and implements of flint, and the most ancient pottery. We believe it impossible to misapprehend or mistake the proofs that flow from modern researches, all of which affirm with an irrefutable eloquence the unity of the human species."

"Recent Research in Egypt." — Dr. W. M. Flinders Petrie in a brief paper calls attention to the important discoveries made by archæologists in Egypt during the years 1895–97. During this short period the known history of the Nile Valley has been carried back a thousand years or more beyond what was previously regarded as the beginning of things. Now we look for the beginning many centuries before the pyramids, probably 5000 B.C., or even earlier.

Miss Fletcher's paper upon "The Import of the Totem," and that by Dr. Fewkes, entitled "A Preliminary Account of Archæological Field Work in Arizona in 1897," have been noticed in the *Naturalist* of January, 1898, and July, 1899.

"A New Group of Stone Implements from the Southern Shores of Lake Michigan" is the title of an attractively illustrated article by Dr. W. A. Phillips. Most of the implements are made from flakes; the trap cobblestones from which they were flaked do not readily lend themselves to the blocking out of blades from nuclei. F. R.

ZOÖLOGY.

Beasts.—The author of *Beasts*[1] belongs to that order of naturalists who, to the dread of housewives and maids and to the delight of all healthy boys, fill their pockets, cupboards, and rooms with reptiles and rodents of every description. From the pages of Mr. Kennedy's book we gather that a young crocodile occupied one shelf of his bookcase, a python another, and a pair of white rats a third. In one corner of the room stood the kennel of an armadillo; a vivarium abounding with salamanders, frogs, and tortoises stood by the window; and from somewhere emerged at night a potto, which became so hilarious that three several policemen roused the inmates of the house to warn them against burglars. The book is made up of short sketches of the interesting ways of all these creatures, and of many more, put together loosely, in a familiar style, the chief characteristics of which are sympathy for the whole range of the animal kingdom and a keen love of humor.

It is when animals refuse to behave after the rules laid down for them in the books that they have the greatest interest for Mr. Kennedy. When a toad, instead of rolling its cast skin into a ball and swallowing it with gusto, as it ought, takes it down "slowly and disgustfully"; when a tadpole "covers itself with ridicule" by trying to jump about before it has cast its long clumsy tail,—then it is that he thinks their actions worth chronicling. The curious awkwardness which some animals display in the capture of their food is the subject of some amusing pages. Worms, in particular, prove a severe test to the intelligence and patience of many of the reptiles. The "crass stupidity" of the lower reptiles prevents the author's interest in their habits from passing into affection. A white rat, however,

[1] Kennedy, Wardlaw. Beasts. Thumb-Nail Studies in Pets. London, The Macmillan Company, 1899. Illustrated with numerous drawings and photographs. 152 pp. Price $1.50.

and a mongoose evidently won a warm spot in his heart. The chapter on the mongoose, in particular, is a charming study of a fascinating subject. The almost human inquisitiveness of the creature, his fondness for toys and love of human fellowship, are lovingly dwelt on. Frequent reference to the need of care and thought for the wants of the creatures which are imprisoned as pets, is evidence of the author's sympathy for them and his acute observation of their habits. The final chapter of the book is on birds, which the author never deprives of their liberty; the chapter is a strong appeal against the terrible destruction of birds for millinery purposes.

A hearty, cheerful tone pervades the book, humorous turns of speech and thought abound, and if the style is now and then almost too colloquial, the fact is explained by the statement that the sketches were originally prepared for a school paper. Happy must be the boys under such a master; it would be hard for the dullest or the most thoughtless to come under his influence without acquiring a keener observation, a wider interest, and a more tender sympathy.

R. H.

Lake Urmi. — The natural history of Lake Urmi in northwestern Persia has been described by R. T. Günther.[1] The lake lies in the highlands that separate the river systems of the Atlantic, the Indian, and the Arctic Oceans and has no outlet. It has been described as "dead," but its waters, though containing about three-fifths as much saline matter as the Dead Sea, harbor a number of organisms. Masses of zoöglœa of micrococci invested by diatoms, and numbers of the brine shrimp, *Artemia urmiana*, find life possible in this water. It was estimated that about twelve hundred Artemias per cubic meter was a fair average for the whole lake. The fresh-water streams flowing into the lake contain fish which, when carried into the lake, are killed by its salinity. The conditions of the fish faunas of the several rivers indicate that the lake has for a long time been an efficient barrier to intercommunication. A description of the land fauna and flora surrounding the lake and a list of the local names of many animals are given. The paper also includes descriptions of the species of animals both recent and fossil collected by Günther, but worked up by other authorities.

P.

[1] Günther, R. T. Contributions to the Natural History of Lake Urmi, Northwestern Persia, and its Neighborhood. *Journ. Linnæan Soc. Zoöl.*, vol. xxvii, pp. 345-453, 1899.

Reissner's Fibre. — This fibre has been found by Sargent[1] to extend from the posterior end of the spinal cord anteriorly through the central canal and the ventricles of the brain to the anterior end of the optic lobes. The fibre was identified in representatives of all the chief groups and subgroups of the vertebrates, upwards of sixty different species having been examined. In no case where the material was perfectly preserved was the fibre absent. The uniformity of the fibre and the fact that it can be demonstrated by a great variety of methods lead the author to the conclusion that it is not an artifact, but a normal structure and probably nervous in character. The paper is accompanied by figures from photographs which demonstrate very conclusively the presence and position of the fibre. P.

Preliminary List of the Mammals of New York. — In 1842 Dr. J. E. DeKay published a work on the mammals of New York, giving descriptions of all the species then known to inhabit the state, with figures of most of them, this work forming Part I of the *Zoölogy of New York*, published under the authority of the state. Since that date no general survey of the mammal fauna of the state had been attempted till the appearance in 1899 of Mr. Gerrit S. Miller's "Preliminary List of the Mammals of New York."[2] As Mr. Miller says: "To write a preliminary paper on this subject fourteen years after the appearance of Dr. C. Hart Merriam's two volumes on the mammals of the Adirondack region, and fifty-six years after the publication of DeKay's elaborate work on the mammals of the state at large, may at first seem paradoxical"; but he gives good reasons for calling his list a preliminary one. He justly claims that "one of the most important results of the recent great increase in our knowledge of the mammalian fauna of New York is the realization that nothing more than preliminary work can be done now. The whole area of the state must receive a thorough biologic survey before final results can be expected." And what is true of New York, it may be added, is equally true of any other considerable area of North America, and probably of any other equal area of the world, so little is really known of mammalian life anywhere. Until within very recent years, the small mammals of no portion of this or any

[1] Sargent, P. E. Reissner's Fibre in the Canalis Centralis of Vertebrates. *Anat. Anz.*, Bd. xvii, pp. 33–44, Taf. I–III, 1900.

[2] Miller, Gerrit S., Jr. Preliminary List of New York Mammals. *Bulletin of the New York State Museum*, vol. vi, No. 29, October, 1899, pp. 271–390. Issued Nov. 18, 1899.

other country were more than superficially known, as witness the large number of new and previously unsuspected forms that have come to light through careful and systematic collecting in even the longest settled parts of the United States.

Not the least interesting part of Mr. Miller's paper is his historical summary of the work thus far accomplished in making known the mammalian life of New York State, in which he traces the gradual advance of our knowledge of the subject from 1842 to the present time. During the forty years immediately following the publication of DeKay's work only three species were added to the list of the state, while eighteen have been added during the last ten years. The total number of known New York mammals has been raised from fifty-six in 1842[1] to eighty-one in 1899, while doubtless others still remain to be added by further research. These additions are mentioned in chronological order, and also shown by a tabular arrangement. Thirty-one species have been described and named from New York specimens, of which twenty are now regarded as synonyms of previously described species. The type localities of all are given on account of their interest from the point of view of systematic zoölogy.

The eighty-one species and subspecies listed by Mr. Miller include eight cetaceans, two seals, and three introduced species of Old World rats and mice. Deducting these leaves sixty-eight species of strictly indigenous land mammals known as inhabitants of the state. In some six or seven instances increase in the total number of forms is due to the recognition of subspecies, two forms being recognized as occurring within the state instead of one, as in DeKay's time, as in the case of the red squirrel, chipmunk, flying squirrel, red-backed mouse, cottontail (three forms instead of one), mink, etc. Lumping these, as was formerly done, would reduce the number of New York mammals to about seventy-three as against the fifty-six known to DeKay.

In other words, the twenty-four additions to DeKay's list include sixteen species and eight subspecies, the latter being in most cases covered by DeKay's names.

The faunal areas, or "life zones" of the state, are considered at length, from the point of view of birds and plants as well as mammals. Following this is the list proper. Under each species are cited the authorities for the names adopted, and all the principal references to the species as New York animals. The text under each species is so arranged and subdivided as to give (1) the type

[1] DeKay gave sixty-five, but nine of these have proved invalid.

locality of the species; (2) its faunal position; (3) its habitat; (4) its distribution within the state; (5) its principal records for the state; and (6) remarks. The distribution of the various species within the state, and the citation of "principal records," are in general given with satisfactory detail. It hence seems strange that Dr. Holder's paper on the Atlantic right whale (*Balæna cisarctica*) should have been overlooked, especially since the paper (*Bulletin American Museum Natural History*, Vol. I, No. 4 (1883), pp. 99–138, Pls. X–XIII) was based primarily on a Long Island specimen, the skeleton of which has been on exhibition for twenty years in New York's greatest Museum of Natural History. A reference to Audubon and Bachman (*Quadrupeds of North America*, Vol. I, p. 148) on the former occurrence of the fox squirrel in New York would perhaps have been of interest.

We regret to see that Mr. Miller adopts Mr. Bangs's proposed change of name for the common deer, from the well-established and familiar Virginianus of Boddaert for Americanus of Erxleben. It would not be regrettable if Erxleben had really used the name in a nomenclatural sense for this deer, which he clearly did not do, or even intend to do. Erxleben says: "Differtne vere Americanus vti Pennanto videtur?" and then gives its differences from *Cervus dama*, and cites the authors who have written of it. As he wrote in Latin he naturally used the word "Americanus" in the sense of, Does the American deer truly differ? etc. The context shows that where he gave names to either species or varieties, they are given as marginal headings, as under, for example, *Cervus elaphus* (*Regni Animalis*, p. 301), where our elk or wapiti is named (p. 305) Canadensis = *Cervus elaphus* γ *Canadensis;* and so on throughout the "Systema Regni Animalis." The case of the common deer, as treated by Erxleben, is thus not at all parallel to that of the elk; in the latter case a name was formally given; in the former, only by a violent distortion of the author's evident meaning and intentions can a name be extracted from Erxleben for the Virginia deer.

Mr. Miller gives also a useful list of the fossil species thus far reported from the state, numbering five, as follows: peccary, horse, elephant, mastodon, and the big rodent Castoroides. A detailed bibliography of 103 titles concludes this interesting and important piece of work. We regret to see, however, that Mr. Miller was compelled to submit to a system of "editing rules in bibliography," so out of harmony with nearly all similar work in zoölogical bibliography, simply because they have been "adopted by the Regents of the University of the State of New York." J. A. A.

The Trail of the Sandhill Stag. — We confess to a feeling of disappointment on laying down *The Trail of the Sandhill Stag*,[1] by Ernest Seton-Thompson. If it had been the first book by that author which had come to our notice, the feeling would probably have been one of interest and pleasure, but the standard set in *Wild Animals I Have Known* was so high that the present story, measured by it, fails to answer our expectations. For such of our readers as have not yet made the acquaintance of Mr. Seton-Thompson's style, the remedy against a similar disappointment is simple; let them begin with the story of the *Sandhill Stag* and then pass to the earlier and more fascinating work. In the story at present under consideration, as in his earlier stories, the author has attempted to tell the life story of a species by painting the portrait of an individual who possesses to an extraordinary degree the characteristics of his kind. In the present instance the subject is a black-tailed deer, a buck of marvellous size, crowned with an enormous pair of antlers. A boy, in whom the old barbarian instinct of the chase is overpowering, catches sight of the beautiful creature and pursues him on various occasions. Finally, after a long three days' chase over the snow, the stag, after seeing his mate murdered by one of the lad's more callous companions, is at last, and in spite of all stratagems, hunted to his lair, and comes face to face with his pursuer. The lad, however, is touched by the expression of nobility in the creature's gaze; his better nature asserts itself, and hunter and his intended victim part with an increase of mutual respect.

The moral of the story is obvious, perhaps too obvious. The service which the author's earlier work has performed in teaching love and sympathy for animals has undoubtedly been enormous, but it was done by revealing in an unusual degree the secrets of the creatures' lives. The reader shared their pleasures and anxieties, and unconsciously became their friend. In this later tale the boy's feelings rather than the stag's are portrayed.

If the story is a little less effective, the illustrations are as charming as ever, and the workmanship of the book itself reflects unusual credit on the designer and the publisher.

It is the hope of all who are watching Mr. Seton-Thompson's work that he may be able to reap, in the field which Mr. Hamilton Gibson tilled so faithfully, a splendid harvest. There is no more

[1] Seton-Thompson, Ernest. The Trail of the Sandhill Stag. With sixty drawings in black and white and a frontispiece in color. New York, Charles Scribner's Sons, 1899. 93 pp. Price $1.50.

effectual way to overcome the general indifference to the sufferings of our fellow-creatures than by spreading a knowledge of their tragic lives.

R. H.

Structure in the Mammalian Egg. — Professor Flemming[1] re-examines the ovarian eggs of the rabbit and finds that thin sections show a real reticulum of stained fibres. Previously, in the fresh eggs, he could not decide whether the fibres he saw branched and anastomosed or not. In the present preparations the yolk granules seem, when smallest, to be imbedded in the fibres, and the author thinks they arise there and only later get into the spaces of the network.

In the cavity of the Graafian follicle there is also a reticulum. This is regarded as the result of coagulation of the follicular liquid by the reagents used. It is not the same in normal as in abnormal follicles and is of a much finer mesh in small follicles. The network in the egg can be distinguished from that in the follicular liquid by its coarser, less regular spaces.

From the illustrations given, the reader might easily infer that the differences between the egg structure and the coagulum were merely of degree and not of kind, and see in them support for Alfred Fischer's contention that the so-called structure-reticulum is itself a coagulum. However, the author believes the egg reticulum to be the same as that seen in fresh material, and hence not the result of coagulation.

E. A. A.

Bob. — *Bob*[2] is a story that will appeal strongly to all lovers of animals. It will appeal also to lovers of literature. It is the story of a poet's mocking-bird told with a delicate humor, a keen and loving sympathy. To Lanier, as to many lovers of birds, there was something repugnant in the thought of caging a wild bird; Bob was, therefore, an unsought though welcome guest. The reader, however, lays down the little volume with the feeling that the bird's liberty could not have been sacrificed in a better cause. In this little volume, and in the sonnets which form the epilogue, Bob has certainly found a memorial such as falls to the lot of few.

The reader will naturally not look for a scientific study, a careful record of the number of feathers shed during the moult, or the

[1] *Festschrift Carl von Kupffers*, Jena, 1899.

[2] Lanier, Sidney. Bob. The Story of Our Mocking-Bird. New York, Charles Scribner's Sons, 1899. With sixteen illustrations in color. 64 pp. Price $1.50.

weight of food taken in a day; but he will find a charming study of the personality of the bird, and many graceful or playful reflections by the way.

The illustrations are from colored photographs, reproduced with an unusually pleasing effect. They represent various young mocking-birds in the attitudes described in the text.

R. H.

Our Native Birds. — This is a book[1] which should be within the reach of every school-teacher and of every person interested in preserving for future generations the wild life which forms so large a part of the attraction which nature exerts. The author begins with some of the statistics, which are now only too easy to obtain, of the steady decrease of song and game birds, and explains with unusual fairness the causes of this diminution. He gives full weight to a consideration very generally overlooked, namely, the destruction of shrubbery and the draining of wet places, incidental to the growth of towns and cities. Subsequent chapters are devoted to a description of the means by which we may prevent the destruction of birds and restock places from which they may have been driven. The better enforcement of the existing laws, or the enactment of new ones, particularly the introduction of gun license to reduce indiscriminate shooting, the spread of interest and knowledge through Audubon societies and the popular magazines and books, are urged with warmth, and at the same time with judgment. Interesting advice as to planting shrubs, vines, and trees, furnishing water for bathing and drinking, and allowing waste places to grow up with something that will furnish food and cover, is evidence of the practical character of the author's mind. The vexed question of the English sparrow's position is also treated with fairness, though many readers will take well-grounded exception to the method recommended for its destruction, *viz.*, the use of poison. The subject of hunting and of encouraging boys to hunt is hardly treated in a manner consistent with the tone of genuine sympathy for animals evident in the rest of the book. Throughout the book there are frequent references to authorities.

There is a marked absence of literary skill, both in the style and in the arrangement of the matter; it is not a book that one would read for amusement or for pleasure, but for those in search of help

[1] Lange, D. Our Native Birds. How to protect them and to attract them to our homes. With illustrations. New York, The Macmillan Company. 162 pp.

and advice in efforts to lessen the frightful destruction of wild life everywhere prevalent, the book will be an encouragement and an assistance.

R. H.

The Tree Frog. — A second interesting contribution to the natural history of European Amphibia by one who loves his subject is to be found in the *Quarterly of the Natural History Society of Zurich*, issued Feb. 15, 1899. H. Fischer-Sigwart, having previously described the life of *Rana fusca*,[1] now tells us of the habits of the tree frog, *Hyla arborea* L. The spawning, larval life, feeding, hibernation, etc., were studied both in the open and in his terrarium, where he kept many of these creatures (some for ten years), with greater satisfaction to himself than to his neighbors, who complained of the noise made by the ardent males. A tabulation of many observations upon the singing of these frogs and the state of the weather does not support the common belief in their powers as weather prophets, though showing that cold, stormy weather checks, as fine, warm weather increases, their musical efforts.

A long series of observations upon their color led to the result that they resembled the background in every case except one, slowly assuming various combinations of yellow, green, brown, gray, bronze, rust-red in harmony with the leaves, earth, cement, iron pipe, etc., they remained upon.

For details we must refer to the twenty-seven pages of the original.

E. A. A.

The Protoplasm of the Salmon Egg.[2] — Professor His has added another study to his previous noteworthy work upon the egg of the salmon. As before, he emphasizes the study of live material, while the interesting photographs that accompany his paper show, as far as photographs can, the appearance of preserved and sectioned material.

The protoplasm that collects in a heap (subsequently to divide into the cells of the blastoderm) acts, when removed from the egg, like a viscid liquid. It is made up of a clear "Hyaloplasma" and a turbid, granular "Morphoplasma." As development proceeds, these two parts undergo progressive changes in relative amount and arrangement. The changes in the distribution of these two parts

[1] See review in the *American Naturalist*, June, 1898.

[2] Protoplasmastudien am Salmodien Keim. *Abh. Königl. Sach. Gesell. Wiss.*, Bd. xxv, 1899.

of the protoplasm and the lack of any fixed permanent structure make one of the main theses of the author's work. His conception of the organization of protoplasm as derived from preserved material and from fresh material is that the Morphoplasm forms a framework enclosing Hyaloplasma in its meshes. In young cells the framework is uniform and fine meshed; later various modifications arise, so that the end result is very different in different cells and organisms. This morphoplasmic framework is continuous with the nucleus, and with the cell wall which is an actual membrane or modification of the framework and connected by radiating strands with the rest of the framework. The Hyaloplasma is a translucent, viscid liquid not visibly acted upon by reagents that act on proteid matter; it is thought to be inert, not living. Where large areas of clear Protoplasma, ectosarc, are seen to be contractile, it is really the Morphoplasma of the limiting membrane and of the few strands that pass through the liquid that is the real agent. When granules are seen moving through the Hyaloplasma they are supposed to be really in unseen strands of Morphoplasma.

The Morphoplasma is full of granules, microsomes, or plasmosomes. These may stand at irregular intervals, and hence there must be some substance to hold them together, *i.e.*, the strand is not merely a row of granules but consists of granules imbedded in a connecting substance supposed to be a viscid liquid not mixing with the Hyaloplasma. Though it is difficult to distinguish microsomes from yolk granules, secretions, etc., yet the author thinks there are real plasmosomes as essential elements of the strands of Morphoplasma. Though thus agreeing with Bütschli, that protoplasm has two non-miscible liquids as basis of its organization, the author does not accept the alveolar theory of structure as accounting for the morphoplasmic framework which is often seen as actual fibrils and not membranes.

As development proceeds, the undifferentiated protoplasm becomes differentiated, the meshes enlarge, the strands thicken and become fewer, and all the various specializations of cell division appear. Of the many interesting details of the latter phenomena here recorded, we will mention only the new interpretation of the well-known ring, or vesicle-like, appearances of the chromosomes as they are coming together in the formation of daughter-nuclei. The author thinks the Morphoplasma is prearranged in meshes of different size in different parts of the cell traversed by the chromosomes in moving from the equator of the spindle to the polar regions, and that when

they pass through the narrow meshed regions they assume a corresponding slender form, to expand later in the wider rings in the region of wider meshwork. The chromosomes are collections of chromatic granules which are arranged on the walls of the meshes, hence they outline a figure corresponding to the shape and size of the mesh. All this, the author concedes, would lend itself to the idea that we are dealing with an alveolar or vesicular structure.

The formation of new cell walls by the thickening and fusing of strands of the framework is apparently similar to the mode of making cell walls in the cleavage of echinoderm eggs as described by G. F. Andrews.[1] And the conception of chromatin granules moving along strands of protoplasm, as do granules in the pseudopodia of rhizopods, is also the same as the flowing or filose movements there described for the interalveolar plasma in various animal tissues and eggs. Considerable space is given to the description of remarkable amœboid movements performed by the cells of the blastoderm; they may send out very long finger-like pseudopodia which are at first chiefly clear Hyaloplasma but may become granular and be withdrawn. These activities, however, are not known in the normal state, but seem to be called forth by the stimuli that come to the blastoderm when removed to a compressorium for observation. Among other interesting observations we will mention only the occurrence of multiple asters in eggs that had not been fertilized, a phenomenon similar to that observed by T. H. Morgan[2] in echinoderm eggs. The unfertilized eggs of the salmon may be kept in running water for weeks without losing life. In the rainbow trout, also, unfertilized eggs were not dead at the end of several weeks.

Sections of such eggs kept seventeen days show numerous asters in which the radiating lines connect with a rather uniform mesh of the morphoplasm or else with the rays of other asters. At the center of each aster is a group of granules, representing the centrosome.

E. A. A.

Embryology of Invertebrates.[3] — The first part of the original German edition of Korschelt and Heider's Embryology of the Invertebrates appeared in 1890, and the last part in 1893. The translation

[1] The Living Substance. *Journ. of Morphol.*, Supplement 1897.

[2] The Action of Salt Solutions, etc. *Roux's Archiv*, Bd. viii, 1897.

[3] Korschelt, Dr E., and Heider, Dr. K. Text-book of the Embryology of Invertebrates. Vol. i translated by E. L. Mark and W. M. Woodworth; vols. ii and iii translated by M. Bernard and revised and edited by M. F. Woodward. The Macmillan Company.

of this monumental work was undertaken by Mark and Woodworth, and the first part of the English edition was published in 1895. Since then the translation has been continued by Matilda Bernard, under the editorship of Martin F. Woodward; and last year two additional parts were issued. The portion of the work thus far rendered into English represents about two-thirds of the German text, the chapters on the mollusks, tunicates, and amphioxus having not yet appeared in translation. From these facts it might be inferred that translation was a more time-consuming process than original composition, but the true explanation is doubtless found in the liberal opportunities given to German teachers for work of this kind as compared with that afforded to Englishmen and to Americans.

The body of the work is well translated, and although considerable freedom is sometimes taken in the adjustment of the substance of a paragraph to its new dress, we have found no place in which this change can be said to have seriously altered the sense. In comparing the several parts, we are inclined to believe that the first is more closely translated than the remaining two.

The arrangement of materials is a model of exactitude. The coarse print, fine print, and notes of the original are rendered as such, and the editor's additions are always clearly indicated by brackets. The more recent literature is usually given in an appendix.

The incorporation of new material was evidently one of the most difficult problems confronting the translators. This naturally has been greatly increased in the last two parts, for the assimilation of almost a decade of embryological work is no small task. As a rule, this has been met by the insertion of the more important new titles in the Literature Appendices, and occasionally by the addition of footnotes. Unsatisfactory as this method often is, it is difficult to see how it could have been improved upon except by a rewriting of the original text.

The way in which Anlage shall be rendered into English is a question that confronts every English translator of German embryological work, and, as the solutions of this question seem to be as numerous as those who attempt it, one is not surprised that the translators of the last two parts should substitute for the word "fundament," used in the first part, their own choice, "rudiment." This calls for some defense, which is given in the preface to the second part, where Darwin's unfortunate use of "rudimentary" for "vestigial" is pointed out as a root of much evil. While this whole matter is one rather of convenience than of importance to the zoölogist, its

influence on future lexicographers must be at least confusing, and should even a small proportion of the terms proposed be adopted, the uninitiated might be led to believe that with a command of Anlage and Zug almost any idea could be expressed in German.

In one respect the English edition is a noteworthy advance over the German original. The latter is paged continuously and is concluded with a subject and an author's index. The English parts have each their own paging, a table of contents, and double indices, thus rendering them much more readily usable as reference books. It is to be regretted that this general improvement has not extended to the presswork. Unfortunately in this respect the English edition is decidedly behind the German. In the first and second parts the illustrations, particularly, lack the clearness of the German cuts, and in the third the muddiness of the figures is often a really serious defect. Notwithstanding these shortcomings, the unabridged translation of such a masterly work is a boon to the English-reading zoölogical student, and one can do no less than wish that good fortune may aid in the completion of so worthy a task. P.

A Recent Book on Insects. — In *Our Insect Friends and Foes, How to Collect, Preserve, and Study Them* (G. P. Putnam's Sons, New York and London, 1899. xix, 377 pp., 225 illustrations), Miss Belle S. Cragin gives directions for collecting, raising, and preserving insects, brief notes on their structure, habits, and habitats, with more detailed notices of some of the commoner forms of hexapods and shorter accounts of related arthropods.

Miss Cragin's book shows a purpose so sincere, and her project is so praiseworthy, that it is especially unfortunate not to be able to commend her effort. The directions for the collection and preservation of insects, though not better than others equally available, do not seriously offend by what they contain or omit. The more detailed accounts, however, show so slight a personal knowledge with the subject that very little can be said in favor of the book as a guide to instruct young students or to quicken their interest in the study of insects.

The essential characteristics for a book on insects, written for young people, are an attractive literary style, clear, concise, and accurate statements arranged in logical, scientific sequence. Judged from this standpoint, Miss Cragin's book cannot be regarded as even moderately successful. It would be hard to find a book dealing with insects in which the orders and families are arranged in so confusing and unscientific a manner. Misleading and inaccurate statements

are frequent. The Coleoptera are said to include over eleven thousand species; a statement that is true, but surely an unhappy way of recording that more than eleven thousand beetles are credited to America, north of Mexico; the larvæ of some snout beetles have jointed legs; the firefly, with luminous thoracic spots, is incorrectly placed in the Lampyridæ; the Hercules beetle is not the largest true insect; more than one Termite is found in North America, and the northern range of the species credited to that region is far beyond Massachusetts; all tropical Phasmidæ do not have wings that look like leaves.

The repetitious character of the text is especially tiresome, and the list of books for reference wholly inadequate.

Finally, the illustrations are very evenly bad; it would take much search to find a more atrocious series. Figs. 89 and 92 are transposed. S. H.

Sheep Tick. — The gross anatomy and histology of the female genital tract of *Melophagus ovinus* are described in detail by Pratt (*Zeitschr. f. wiss. Zool.*, Vol. LXVI, pp. 16–42, Pls. II, III), completing and extending the work of Leuckart (1858). Each ovary consists of two ovarioles, possessing two follicles apiece, and both ovaries and ovarioles alternate in the production of the ova. From the germarium are produced follicular, nutritive, and egg cells; while the ovarioles are similar to those of Musca, and the peritoneal covering of the ovary is peculiar only in its thickness and extent. The fused proximal portions of the oviducts form a median vessel serving as a receptaculum seminis and lying in the virginal female in a plane perpendicular to that of the uterus, later at an acute angle to it. The ducts of the two pairs of milk glands, which provide nourishment for the larva during intrauterine development, open by a single opening into the uterus; the anterior of the two pairs is more or less rudimentary. The structure of the vagina is such as to permit of extreme distention at the time that the fully developed larva is extruded. R. H. Wolcott.

Nauplius Stage of Penæus. — Although F. Müller announced as early as 1863 that Penæus emerged from the egg in its nauplius stage, this statement remained unconfirmed, notwithstanding the fact that Penæus has been studied by several investigators, till the past year when Kishinouye[1] rediscovered this stage in material collected on the Japanese coast.

[1] Kishinouye, K. On the Nauplius Stage of Penæus. *Zool. Anz.*, Bd. xxiii, pp. 73, 74, 3 Figs., 1900.

Sense Organs of Nereis. — F. E. Langdon[1] has described three kinds of sense organs in the skin of *Nereis virens* Sars. The diffuse sense organs consist of groups of bipolar nerve cells whose bodies form a part of the external epidermis, whose peripheral ends extend as sense bristles into the surrounding water, and whose central projections are in the form of nerve fibres terminating probably as pericellular nerve baskets around ganglion cells in the central nervous organs. The diffuse sense organs are most numerous in those parts of the body most exposed to contact, and represent organs for mechanical and possibly chemical stimulation. The prostomium possesses an anterior and a posterior pair of cephalic organs, each of which consists of a group of bipolar cells whose peripheral processes end in the epidermis, and whose central processes terminate in the brain. The anterior pair differ from the posterior in that their cell bodies lie between epidermis and brain instead of in the brain. The third class of organs consists of groups of spirally arranged cells, hence called spiral organs. The central processes from these organs take a direction appropriate for nerve fibres, but have not been traced into nervous organs. Their function as epidermal eyes is, therefore, hypothetical.

P.

Breeding Infusoria. — As bearing upon the problem of death it is interesting to note that the doctor's thesis of Dimitri Jonkowsky[2] records some partial repetition of Maupas's famous work upon Infusoria. Maupas found degeneration and death befell many Infusoria when they were bred for many generations without conjugating, but that the change in the nuclear machinery that takes place in conjugation would start another long series of generations. That degeneration is necessary without such renewal seems less probable from the experiment of the present author, though his evidence is not conclusive. In the case of *Pleurotricha lanceolata* (Ehbg.) 458 generations were reared in eight months and yet no degeneration was found, except in a few cases in the last generation. He suggests the rapidity with which the animals breed, which was greater in Maupas's experiments, may be a factor in the occurrence of degeneration. Bearing in mind the sensitiveness of many Infusoria to the chemical and physical nature of the liquid they are reared in, it seems not unlikely that degeneration may depend upon other

[1] Langdon, F. E. The Sense Organs of Nereis virens, Sars. *The Journ. of Comp. Neurology*, vol. x, No. 1, pp. 1–77, Pls. I–III, 1900.

[2] *Verh. des Naturhist. med. Verlins zu Heidelberg*, Bd. vi, 1898.

factors than the lack of conjugation, and that we do not yet know any limit to the length of life these creatures may have under proper conditions.

E. A. A.

Swiss Infusoria. — The school of Swiss zoölogists at Geneva, under the able leadership of Professor Yung, has in recent years shown great activity in the investigation of the local fauna. This work has been of high order and is abundantly illustrated with lithographed plates. That an interest in the Infusoria would still linger in the home of Claparède is indeed to be expected, though a list of new genera and species of Ciliata from the environs of Geneva comes as a surprise. Nevertheless Dr. J. Roux has discovered there a dozen new ciliates whose structure and relationships he discusses at length in a recent paper.[1] He also describes and fully figures a score of other forms concerning which his studies have added important information. Of prime interest is his *Monomastix ciliatus* — a new member of the Mastigotricha which combines characters of the Ciliata and Flagellata, having the cilia and nuclear conditions of the former and the flagellum of the latter. An amplified description is given of *Lionotus vesiculosus* Stokes, originally described as from this country. The discussion of *Loxodes rostrum* sheds light on a number of controverted points; the animal is flattened dorso-ventrally, not laterally, and the peristome is ventral, though placed to the left, being bordered by fine cilia and transverse striæ which have heretofore been interpreted as long cilia. The genus should be removed from the Trachelina to a new family, Loxodina. Various American species of this genus have been ill-founded, resting merely on inconstant variations in color, number of nuclei, and excretory vacuoles. On account of its superb illustrations and the critical character of the discussions, this paper is of especial value to all American workers in this much neglected group, and it is to be hoped that Dr. Roux will continue his studies.

C. A. K.

Growth in the Rhizopodan Shell, after its formation at the time of the division of the parent, as maintained by Rhumbler, is contested by Penard in a recent paper.[2] In observed cases in a

[1] Roux, J. Observations sur quelques ciliés des Environs de Genève, avec la description de nouvelles espéces. *Rev. Suisse de Zoöl.*, tome vi, pp. 557–636, Pls. XIII, XIV, 1899.

[2] Penard, E. Sur la croissance supposée de la coquille chez les Thécamœbiens. *Arch. Sci. Phys. et Nat.*, IV Pér., tome vii, 23 pp., 1899.

number of species the new shell is usually as large as the older one, and when differences do occur, they are but slight and as often present larger shells as they do smaller ones. The differences in size among the individuals of a given species in one locality are usually small, the greatest number presenting the medium dimensions, while dwarfs and giants are equally rare. These extremes are examples of variation within the species and cannot represent the young and the old — the extremes of a growth series. The instances cited by Rhumbler of great differences in size are explained by the supposition that more than one species has been included in the series, the author contending here, as elsewhere, for the recognition of a greater number of species in this group. The process of repair, local growth about the mouth, resolution of the shell, and exuviation are none of them regarded as proofs of the growth of the shell as a whole. The author's extended observations on the Rhizopoda thus lead him to confirm the views of Verworn.

C. A. K.

Abyssal Rhizopoda. — Dr. E. Penard has recently published[1] an account of his interesting studies upon the Rhizopoda from the bottom of Swiss lakes. His attention was given to collections of the bottom ooze, from which he describes a characteristic fauna of peculiar species. Many of these are new, differing from the littoral species to such an extent as to necessitate, in the author's estimation, varietal or specific distinction. In numbers they exceed the stragglers from the shore fauna which occasionally invade the depths. The author does not favor the view that the Rhizopoda are sometimes pelagic in habit, and suggests that their floating is due to the gases of putrefaction. This is certainly not the case in some American waters where their numbers and activity entitle them to rank as planktonts. The abyssal Rhizopoda are most abundant at depths of 25–50 meters, being modified by shore contamination above that limit, and decreasing in numbers below it. Their distribution is widespread, though irregular as to species. During the winter season they decline in numbers as their food, the diatoms, is at a minimum at that time. In addition to the Léman, eight other Swiss lakes were explored, and the same types of abyssal Rhizopoda were found in all of them. This fauna, living under almost unchanging conditions of great pressure, low temperature (about 4° C.), little or no light, no currents, and little food but diatoms, exhibits certain

[1] Penard, E. Les rhizopodes du Lac Léman. *Rev. Suisse de Zoöl.*, tome vii, pp. 1–142, Pls. I–IX, 1899.

peculiarities. As compared with littoral species, those of deep water are more variable, being often irregular in shape or ornamentation, Quadrula, for example, lacking the regular arrangement of the plates of the shell. They are also of larger size, and are more transparent, being less heavily charged with salts of iron and manganese, which cause the brownish and purplish tints of the shell. The contractile vacuoles are less active, as they are in those species also which inhabit sea-water, and the capacity of encystment seems in large measure to have been lost. Starch grains are frequently found in the protoplasm, though no Zoöchlorellæ were detected. The author suggests that diatoms may be retained within the protoplasm for a considerable length of time undigested in a temporary symbiotic relationship. On account of the great similarity of the abyssal Rhizopoda of the different lakes not at present connected, the separate origin of these faunas from the common littoral group is not accepted, and the idea is advanced that they represent a relict fauna of the preglacial or glacial period.

C. A. K.

A New Colonial Flagellate. — The Illinois State Laboratory of Natural History has recently issued a bulletin[1] on *Platydorina caudata*, an interesting new genus of the family Volvocidæ, described by C. A. Kofoid. This is a colonial form of sixteen or thirty-two biflagellate cells arranged in a horseshoe-shaped cœnobium which bears three or five tails, formed by the envelope at the posterior end. The cœnobium is flattened, and is slightly twisted in a left spiral. The cells appear to be arranged in one layer, and the two faces of the plate are exactly alike, as alternate cells upon either face bear flagella. In development the young colonies pass through a Gonium and a Eudorina stage and subsequently flatten, so that the cells of the two faces are regularly intercalated. This genus presents the most pronounced type of functional and structural polarity, and exhibits a greater degree of axial differentiation than any other genus of the family. The organism has been found in late summer and fall months for four years past, and has occurred in the waters of the Upper Mississippi, Illinois, and Wabash basins. The paper contains a key to colonial Volvocidæ.

[1] Kofoid, C. A. Plankton Studies. III. On Platydorina caudata, a new Genus of the Family Volvocidæ, from the Plankton of the Illinois River. *Bull. Ill. State Lab. Nat. Hist.*, vol. v, pp. 419–440, Pl. XXXVIII, 1899.

Sporulation in Amœba. — C. Schee1[1] describes and figures a most interesting method of reproduction in *Amœba proteus* observed in the winter of 1897–98. The conditions leading to this hitherto unknown method of rapid increase in this fresh-water Amœba could not be determined, nor could various experiments bring about the same results in material from the same locality, examined in 1898–99.

The Amœba was studied both alive and in prepared sections and a pretty complete series of stages obtained.

The creature draws in its pseudopodia, takes on a spheroidal form, and then secretes a cyst or case that ultimately shows three successive layers. Within this the Amœba rotates rapidly, once a second, in all directions with frequent change; it looks as if ciliated, but no evidence of cilia was found, and its motions may be due to pseudopodia. After several days this rotation ceases.

In one case a contracting vacuole was seen discharging rhythmically to the exterior, when the cyst was partly formed.

The nucleus divides into pieces, and when there are about 20–30 they become arranged near the surface. These in turn continue to divide until 500–600 small nuclei are formed in the outer part of the Amœba, while the central part has none. Cell walls appear about the nuclei, first about the outermost ones, and gradually the pieces of protoplasm so circumscribed separate as small Amœbas. These break out through the cyst, which has in the mean time become softened and broken up.

The whole process lasts from two and a half to three months.

In this way hundreds of small Amœbas, 10–14 μ in diameter, are set free at one time.

The author was able to isolate the young and rear them to recognizable *Amœba proteus* in two and a half to three weeks. E. A. A.

Notes. — The second number of Vol. I of the *Biological Bulletin* contains the following articles: "The Early Stages in the Development of the Hypophysis of *Amia calva*," by J. M. Prather; "An Extraordinary New Maritime Fly," by V. L. Kellogg; "On the Variation in the Position of the Stolon in Autolytus," by P. C. Mensch; "Gordiaceæ from the Cope Collection," by T. H. Montgomery, Jr.; and "A Preliminary Account of the Spermatogenesis of *Batrachoseps attenuatus*, Polymorphous Spermatogonia, Auxocytes, and Spermatocytes," by G. Eisen.

[1] Beiträge zur Fortpflanzung der Amoeben. *Festschrift Carl von Kupffers*, Jena, 1899.

The first number of Vol. X of the *Journal of Comparative Neurology* contains "The Sense Organs of Nereis virens, Sars," by F. E. Langdon; "The Roof and Lateral Recesses of the Fourth Ventricle, Considered Morphologically and Embryologically," by J. A. Blake; "Observations on the Weight and Length of the Central Nervous Organs and of the Legs in Frogs of Different Sizes," by H. H. Donaldson and D. M. Schoemakér; and "A Report of the Neurological Seminar of the Marine Biological Laboratory, Woods Holl, Mass., for the Season of 1899," by A. D. Morrill. The number also contains an obituary notice of Fanny E. Langdon, by Professor Reighard, and the usual literary notices.

Miss K. J. Bush has published in the *Proceedings of the Academy of Natural Sciences* of Philadelphia a description of a number of new species of gastropods belonging to the genus Turbonilla from the western Atlantic fauna. The paper includes a synoptic list of species and a thorough revision of the synonymy, based upon examination of a number of museum collections.

Dr. S. Prowazek has published in Vol. XI of the Vienna *Arbeiten* a very exhaustive and fully illustrated account of the conjugation of *Bursaria truncatella*. He also contributes many interesting observations on the structure, nutrition, excretion, encystment, conjugation, division, and parasites of *Stylonychia pustulata*.

The Echinorhynchi parasitic in Cetacea have been brought together in a critical discussion by Shipley (*Arch. Paras.*, Vol. II, pp. 262–269).

In a paper on the Porocephali of the dog and some other mammals, Neumann[1] shows that, contrary to the generally accepted belief, the larval forms of these parasites are not accustomed to abandon their cysts, but probably perish in them, and that, except in rare cases, they are harmless to their hosts. The larval form of *P. constrictus*, which is recorded as a dangerous parasite of man in Africa, is probably as innocuous as other species, and certainly was not the cause of death in the cases reported.

A revision of the Echiurida and a discussion of their geographical range are appended by Shipley[2] to his account of the forms collected

[1] Neumann, G. Sur les Porocephales du chien et de quelques mammiferes. *Arch. Paras.*, tome ii, No. 3, pp. 356–361, 1899.

[2] Shipley, A. E. On a Collection of Echiurids, etc. A. Willey's *Zoöl. Results*, pt. iii, pp. 335–356, 1 plate, May, 1899.

by Dr. Willey. He lists a total of thirty-one good species, belonging four to Bonellia, four to Echiurus, one each to Hamingia and Saccosoma, and twenty-one to Thalassema, for which genus a good analytical key is given. From the geographical distribution some interesting points are excerpted. Bonellia favors warmer or temperate waters; Echiurus, colder regions in both hemispheres, without known species in connecting regions; Hamingia and Saccosoma are both northern forms. Of Thalassema the only species found outside of tropical and subtropical seas occur at points under the direct influence of the Gulf Stream.

A gape worm, Syngamus, has been reported by Railliet (*Compt. Rend. Soc. Biol.*, March 4, 1899), which, like that recorded by von Linstow (*Amer. Nat.*, Vol. XXXIII, p. 903), infests herbivorous mammals; it appears to be common in Annam cattle, but, unlike its avian congeners, harmless.

The rhynchodæal glands of Tetrarhynchus have been subjected to a careful study by Pintner.[1] These glands, which correspond to the greater part of the structures interpreted by Lang as rudimentary salivary glands, stand in close relation to the probosces, that is, to organs which are peculiar to a well-circumscribed group of animals aberrant in character. Their distribution, form, and chemical reaction show them to be most closely related to the cephalic glands of nemertines. They are neither cystogenic, nor mucous glands, and no evidence was found as to their real function.

Simondsia paradoxa, the extraordinary nematode described by Cobbold, has been found again by von Rátz (*Zeitschr. f. Thiermed.*, Bd. III, pp. 322–329), whose brief report covers chiefly pathological data.

A monograph on the Strongylidæ adds another to the valuable series of taxonomic summaries on groups of parasites, published by Stossich.[2] An analytical key to the subfamilies and genera is followed by descriptions of the species. The references to the literature on each species are particularly full, but the nomenclature is open to some criticism. A comprehensive list of hosts and a good index, including synonyms, add much to the usefulness of the paper.

[1] Pintner, Th. Die Rhynchodäaldrüsen der Tetrarhynchen. *Arb. Zool. Inst. Wien*, Bd. xii, pp. 1–24, 3 plates, 1899.

[2] Stossich, M. Strongylidæ. Lavoro monografico. *Bull. Soc. Adriat. Sci. Nat. Trieste*, vol. xix, pp. 55–152, 1899.

BOTANY.

The Cyclopedia of American Horticulture.[1] — It has been the dream of years with Professor Bailey of Cornell to close the nineteenth century with a comprehensive index to American horticulture, viewing plants from the garden rather than the herbarium, and considering them as living, growing, varying things rather than bibliographical formulæ. To this end he spent a year in indexing all of the prominent American plant and seed catalogues, as a preliminary step, and then enlisted the interest and services of a large number of artists, expert gardeners and botanists, with whose coöperation he now has the work so well in hand that the first of the four volumes of which it is to consist is given to the public with the promise that the others shall be issued before the end of the year.

The volume already published, covering the initials *A* to *D*, is a quarto of over 500 pages, illustrated by a number of full-page plates, and nearly 800 cuts in the text; and, as is the plan of the entire work, is made first hand, from original sources of information, the botanical matter nearly all newly elaborated from the living plants, and the cultural directions often repeated by several growers experienced in methods adapted to American conditions. The editor very modestly says that he considers his book only a beginning, bringing together scattered data as a foundation for other studies. It is sufficient to say that it is well written, well printed, and, though unequally so, well illustrated.

The botanical treatment of so large and shifting a subject as the plants cultivated in a given country is a matter of some interest. Florists' and gardeners' varieties, because of their very transient nature and great number, are not characterized nor even enumerated, though the types under which they may be grouped are considered in the more popular genera of the moment. But the species and more permanent varieties are systematically handled, and the very real objection, that the systematic treatment of the plants grown in a single country deals with too shifting a quantity to have value of any permanence, is to a certain extent met by the introduction under the more important genera of supplementary lists of species which should be, or are likely to be, elements of our trade.

Nomenclature in botany is sufficiently difficult and complex to

[1] Bailey, L. H., and Miller, Wilhelm. Cyclopedia of American Horticulture. New York, The Macmillan Company, 1900.

furnish occupation for a large number of thinkers and writers, and when the transient forms evolved under the hand of man and advertised and marketed in accordance with prevalent business methods have to be taken cognizance of, it becomes almost a pigs-in-clover proposition. For some years past the leaders in horticultural thought have been agreed on the adoption of simple and short vernacular names for such forms, and official action tending to secure a consistent application of principles of good taste, good sense, and business wisdom has been taken at various times by the American Pomological Society, the representatives of the principal experiment stations, and the Society of American Florists, while in 1893 a botanical congress at Madison, on the report of a committee of international membership, endorsed the actions of these bodies with the recommendation that, for practical reasons, the great Index Kewensis be taken as the basis of nomenclature for the more permanent forms bearing Latinized names. These various conclusions have been made the working basis of the *Cyclopedia*, and although the partitioning of the work among many persons has made the results attained less uniform than would have been the case if one person had done it all, the book is going to place in the reach of makers of American trade catalogues a model which they can follow, and which it will be to their ultimate business interest to follow; while such action on their part will do very much to raise the semi-science of the botany of cultivated plants to a position where the general monographers of plants can take cognizance of and utilize its great array of facts — a result which in one way or another the first half of the twentieth century must see achieved.

T.

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